



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**MAKING A GOOD GROUP DECISION (LOW RISK) IN
SINGAPORE UNDER AN ENVIRONMENT THAT HAS
TIME AND COST CONSTRAINTS**

by

Sok Hiang Candy Loo

September 2014

Thesis Advisor:
Second Reader:

Gary O. Langford
Douglas Nelson

Approved for public release; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			<i>Form Approved OMB No. 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE September 2014	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE MAKING A GOOD GROUP DECISION (LOW RISK) IN SINGAPORE UNDER AN ENVIRONMENT THAT HAS TIME AND COST CONSTRAINTS			5. FUNDING NUMBERS	
6. AUTHOR(S) Sok Hiang Candy Loo				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB protocol number ____N/A____.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			12b. DISTRIBUTION CODE A	
13. ABSTRACT (maximum 200 words) Organizations in Singapore operate in a highly competitive and fast-paced work environment that presents decision-making challenges at the individual, group, and organization levels. A key problem is achieving good decision fitness within time and cost constraints. While many decision-making theories and processes address the fundamental decision-making process, there is limited research on improving the group decision-making framework to eliminate bias and promote effective communication. Using a collaborative approach built on systems engineering and decision-making theories, this thesis aims to improve the group decision-making framework to ensure good decision fitness and proper risk management. This thesis discusses how organizations in Singapore can make group decisions under time and cost constraints by leveraging efficient communication of information, considering the critical elements to ensure good decision fitness, and managing the decision loss quality through the computation of risk value.				
14. SUBJECT TERMS group decision making; decision quality; decision fitness			15. NUMBER OF PAGES 109	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited

**MAKING A GOOD GROUP DECISION (LOW RISK) IN SINGAPORE UNDER
AN ENVIRONMENT THAT HAS TIME AND COST CONSTRAINTS**

Sok Hiang Candy Loo
Civilian, ST Kinetics
B. Eng. (Mechanical), National University of Singapore, 2007

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS ENGINEERING

from the

**NAVAL POSTGRADUATE SCHOOL
September 2014**

Author: Sok Hiang Candy Loo

Approved by: Gary O. Langford, Ph.D.
Thesis Advisor

Douglas Nelson, Ph.D.
Second Reader

Cliff Whitcomb, Ph.D.
Chair, Department of Systems Engineering

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

Organizations in Singapore operate in a highly competitive and fast-paced work environment that presents decision-making challenges at the individual, group, and organization levels. A key problem is achieving good decision fitness within time and cost constraints. While many decision-making theories and processes address the fundamental decision-making process, there is limited research on improving the group decision-making framework to eliminate bias and promote effective communication. Using a collaborative approach built on systems engineering and decision-making theories, this thesis aims to improve the group decision-making framework to ensure good decision fitness and proper risk management. This thesis discusses how organizations in Singapore can make group decisions under time and cost constraints by leveraging efficient communication of information, considering the critical elements to ensure good decision fitness, and managing the decision loss quality through the computation of risk value.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

I.	INTRODUCTION.....	1
A.	CURRENT DECISION PHENOMENON IN SINGAPORE	1
B.	DEFINITION OF GROUP DECISION-MAKING.....	4
C.	IMPACT OF GOOD DECISION FITNESS	7
D.	APPROACH OF THESIS.....	8
II.	LITERATURE REVIEW	9
A.	DEFINITION OF GROUP AND GROUP DECISION MAKING	9
B.	IMPORTANCE AND IMPACT OF A GROUP DECISION	11
1.	Impact of a Group Decision	13
C.	TYPES OF PROBLEMS.....	14
1.	Components of Problems	14
2.	Classification of Problems	15
D.	FACTORS AFFECTING GROUP DECISIONS	17
1.	Decision Fitness	17
a.	<i>Appropriate Frame.....</i>	<i>17</i>
b.	<i>Creative, Doable Alternatives</i>	<i>18</i>
c.	<i>Meaningful and Reliable Information</i>	<i>18</i>
d.	<i>Clear Values and Tradeoffs.....</i>	<i>19</i>
e.	<i>Logically Correct Reasoning</i>	<i>19</i>
f.	<i>Commitment to Action</i>	<i>20</i>
2.	Factors.....	20
a.	<i>First Factor: Communication</i>	<i>20</i>
b.	<i>Second Factor: Process of Decision Making.....</i>	<i>21</i>
c.	<i>Third Factor: Leadership</i>	<i>23</i>
d.	<i>Fourth Factor: Human Factors</i>	<i>23</i>
e.	<i>Fifth Factor: Heuristics.....</i>	<i>24</i>
f.	<i>Sixth Factor: Organizational Culture.....</i>	<i>26</i>
E.	HIGHLIGHTING AND CONTRASTING THE ORGANIZATIONAL ENVIRONMENT IN SINGAPORE.....	28
1.	Globalization	28
2.	Emerging Priorities of Singapore-Based Organizations	29
3.	Structural Change in Organizations	30
4.	Cultures.....	31
F.	DEFINITION OF LOW RISK	33
III.	SCOPE	35
A.	CONTEXT.....	35
1.	Good Decision.....	35
2.	Manage Risk	35
3.	Time and Cost Constraints	39
B.	SYSTEMS ENGINEERING APPROACH	40
IV.	ANALYSIS	41

A.	PRINCIPLES	41
B.	THEORIES.....	42
C.	MODELS	46
D.	APPROACHES	47
E.	METHOD	48
F.	FRAMEWORK.....	54
	1. Assumption 1: Assumption of Self-Regulation	54
	2. Assumption 2: Assumption of Integration.....	55
	3. Assumption 3: Assumption of Manifest and Latent Functions	55
G.	ANALYSIS	61
	1. Current Group Decision Making Framework in an Organization.....	61
	2. Bias	61
	3. Stakeholders	67
	4. Risk.....	75
	5. Heuristics	81
V.	CONCLUSION	83
	LIST OF REFERENCES	85
	INITIAL DISTRIBUTION LIST	89

LIST OF FIGURES

Figure 1.	Two dimensions of complexity (from DQ101 Introduction to Decision Quality, SDG 2014).	2
Figure 2.	Model of one person making the group decision.....	10
Figure 3.	Model of majority-rule in decision making.	10
Figure 4.	Model of achieving 100 percent consensus in a group decision.....	11
Figure 5.	Problem classification matrix (from Joseph 2013).	17
Figure 6.	Human factors in the literature (from Bright 2010).....	24
Figure 7.	Heuristics with indication of respective literature sources (from Bright 2010).	25
Figure 8.	Overall risk is a function of its components (from Kerzner 2013).	36
Figure 9.	Visual framework to evaluate risk and knowledge (from lecture on Life cycle Management Praxis, Langford 2014).	37
Figure 10.	Event-Space Strings (from Langford, Horng, and Lim 2007).	37
Figure 11.	Typical mental process for decision making (from Langford 2014).	47
Figure 12.	Flowchart for group decision-making – Part 1 of 3.....	51
Figure 13.	Flowchart for group decision making – Part 2 of 3.	52
Figure 14.	Flowchart for group decision making – Part 3 of 3.	53
Figure 15.	Proposed group decision-making framework.	59
Figure 16.	Strong Structural Cohesion = Recursive Connection + Weak Coupling.	60
Figure 17.	Chain Communication Network.	60
Figure 18.	Wheel Communication Network.	60
Figure 19.	Current framework for making group decisions in an organization.	64
Figure 20.	External influences.....	65
Figure 21.	Resulting bias in interaction that affects decision quality.	66
Figure 22.	Proposed interaction between decision making group and its parent organization.....	69
Figure 23.	Framework for objective causalities (from Langford 2012).	70
Figure 24.	Integrative Systems Framework 3x3 (from Langford 2012).	71
Figure 25.	Proposed framework for interaction between organization and key stakeholders.....	72
Figure 26.	Proposed interaction between decision-making group and key stakeholders – Framework 1.	73
Figure 27.	Proposed interaction between decision-making group and stakeholders – Framework 2.	74
Figure 28.	Pareto-efficient negotiation – Quality loss function (from Langford 2012)....	77
Figure 29.	Smaller-the-Better (STB: $y = x$, seller) and Larger-the-Better (LTB: $y = 1/x$, buyer).	78
Figure 30.	Combining two loss distributions that compete for a definitive product upgrade period, m	79
Figure 31.	Trigger for making new group decision.....	80
Figure 32.	Comparison of loss functions.....	81

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

Table 1.	List of basic needs with respective specific cultural reactions (from Sztompka 1974).	45
Table 2.	List of derived needs with respective specific cultural reactions (from Sztompka 1974).	46
Table 3.	Matrix of Likelihood and Consequence.	75

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

AoA	analysis of alternatives
DDI	Development Dimensions International
DM	decision making
EMMI	energy, matter, material wealth, and information
ERM	enterprise risk management
LTO	long-term orientation
MP	mathematical programming
NPS	Naval Postgraduate School
OR	operations research
SDG	Strategic Decisions Group
STO	short-term orientation

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

Since 2000, rapid advances in technology have “shrunk” the world and have motivated organizations to enhance their ability to compete globally. Within this competitive environment, organizations in Singapore are under increased pressure to make effective decisions under rigid time and cost constraints. In particular, the ability to address both organizational and analytical complexity is of great importance to decision makers. This awareness helps decision makers to resolve conflicts and gain agreement among the participants in a decision-making group.

There are positive and negative impacts to promoting group decisions. Studies have shown that the exchange of opinions and generation of alternatives by different functional members in a group result in collaborative decisions that are found to be better than decisions made by an individual (McClung 2002a). In addition, a study module in the Fundamentals of Engineering Project Management Course (SI3400) taught at the Naval Postgraduate School (NPS) mentioned that better decision quality is achieved by decision makers when a group of stakeholders contributes to the decision-making process rather than when one individual makes the decision. On the other hand, the presence of bounded awareness and groupthink can establish biases and sway the decision outcome.

Strategic Decision Group (2014) identified six factors that affect decision making—communication, the decision-making process itself, leadership, human factors, organizational cultures, and decision quality elements. These factors affect the quality of a decision and underscore the fundamental stumbling block to achieving good decision fitness. A good decision fit is made through systematic consideration of a comprehensive set of alternatives. Decision fitness helps determine the selection that results in maximum satisfaction of the stakeholders’ needs. There are six quality elements that contribute to the decision fitness chain (Strategic Decisions Group 2014), including *appropriate frame*; *creative, doable alternatives*; *meaningful and reliable information*; *clear values and tradeoff*; *logically correct reasoning*; and *commitment to action*. Their research indicates that the quality of a decision is only as good as the weakest link in the decision quality

chain. A 100 percent quality decision is achieved when additional effort is not required to improve the quality.

The thesis develops a framework that provides guidance to the process of making a group decision that ultimately results in the emergence of a good decision quality under time and cost constraints. In particular, risk management is considered during the iteration of group decision making. In summary, making a good decision means collecting the appropriate and essential information, knowing what level of trust to impart to that information, applying the appropriate framework for evaluating the information, incorporating the ethical and legal with each alternative solution, understanding the risks involved with each alternative before making the decision, and assuring that the decision indeed applies integrally and causally to the problem or question that precipitated the need for a decision.

List of References

McClung, D.M. "The Elements of Applied Avalanche Forecasting Part I: The Human Issues." *Natural Hazards* (2002): 111–129.

Langford, G.O.. Lecture. *DQ101 Introduction to Decision Quality*. Naval Postgraduate School, Monterey, CA, 2009.

ACKNOWLEDGMENTS

This thesis is dedicated to my family, who has always been very supportive during my course of study. This thesis is also dedicated to my advisor, Professor Gary Langford, who has provided valuable advice and inspiration to learn more. His time and effort spent during each review is greatly appreciated.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

A. CURRENT DECISION PHENOMENON IN SINGAPORE

Adapted from Thomas Friedman's *The World is Flat*, Globalization 3.0 is taking place now (Yale 2014). Globalization is defined as the process of interaction and integration among the people, companies, and governments of different nations, a process driven by international trade and investment and aided by information technology (Levin Institute 2014). Globalization also has effects on the environment, culture, political systems, economic development, and human physical well-being in societies around the world.

Reviewing history, Friedman discussed the evolution of globalization from phase 1.0 to phase 3.0 (Friedman 2005). Globalization 1.0 occurred from 1492 to the early 1800s, reducing the world from a large to a medium size. Through exploration, imperialism, and colonialism, the dynamic force was that of countries focused on globalization and how the world could be “flattened.” Globalization 2.0 occurred from 1800 to 2000, shrinking the world from medium to small. The focus was on multinational organizational globalizing and “flattening” the world through the spearheading of efforts to conquer markets and labor. A “flattened” world is characterized by the absence of hierarchy in organizations. In 2000, Globalization 3.0 began, shrinking the world from small to tiny. The current globalization focus is on the ability of individuals and small groups to compete globally. The world has shrunk such that the time taken to carry out transactions and communication locally and globally is shortened. With intense competition in this working environment, it becomes necessary for groups to handle decision situations under time and cost constraints.

Development Dimensions International (DDI) is the pioneer in assessing behavioral data for improving business decisions and one of the top talent management consultancies (DDI 2014). DDI helps transform the way companies hire, promote, and develop the talent in their workforce. According to research carried out by DDI, Singapore made the decision to diversify from its earlier emphasis on manufacturing and

export-oriented industries to pursue growth and prosperity through service and knowledge-based sectors (Busine, Till, and Dy-Liacco 2010). Excellence in leadership coupled with the ability to achieve good decision fitness, according to the Strategic Decisions Group (Strategic Decisions Group 2014), becomes the fundamental prerequisite to success in the competitive global marketplace.

With the evolution of globalization, the ability to address both organizational and analytical complexity is of great importance to decision makers (Parnell, Bresnick, Tani and Johnson 2013). As shown in Figure 1, the competence to deal with both organizational and analytical complexity helps decision makers resolve conflicts and gain agreement among the participants in a group. An increase in the number of differences and conflicts between participants in decision making results in a more rigorous decision-making process. Similarly, increasing analytical complexity in the parameters comprising a decision means a more rigorous decision-making process.

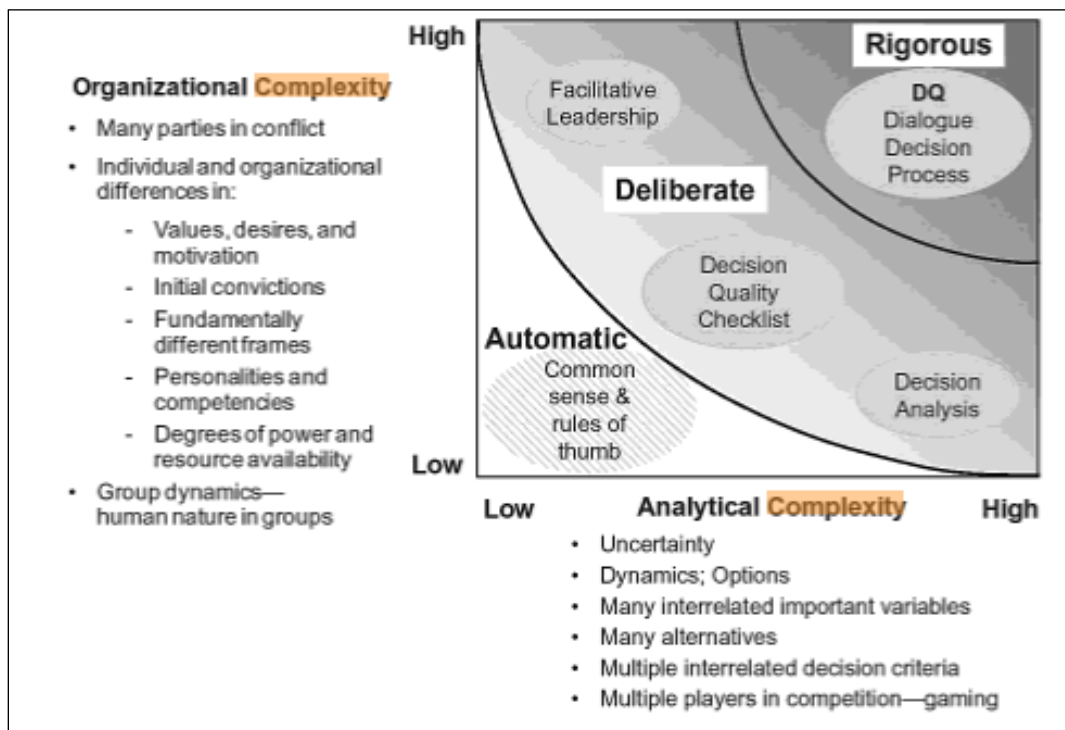


Figure 1. Two dimensions of complexity (from DQ101 Introduction to Decision Quality, SDG 2014).

Against a backdrop of increased organizational and analytical complexity in the business environment, the heightened scrutiny of stakeholders, and a well-publicized shrinking labor market, Singapore must remain systematic in her identification and preparation of leaders and decision makers. Singapore's relatively small population size, limited land mass, lack of natural resources, and high dependency on imported goods drive an intense determination to continue their successful increase in their enviable Gross National Product. The Gross National Product represents the total value added within the domestic production chain, exclusive of the cost of materials and purchased parts and services) plus the net income received from out-of-country sources. Stakeholders in the "business" of Singapore include financiers, customers, company shareholders, and employees. Thus, in light of the evolution in globalization, technology, and stakeholder needs, chosen talent needs to be equipped with the essential capability, experience, knowledge, and self-actualization to deliver economic and commercial value.

The trend research done by DDI concluded that future leaders and decision makers were not prepared to face the following five key challenges (Busine, Till, and Dy-Liacco 2010):

- Drive growth through local and global expansion (multi-pronged strategy);
- Drive operational efficiency and profitability (tactic);
- Cultivate innovation (approach);
- Enhance customer relationships and focus (approach);
- Engage and inspire people (approach).

Currently, DDI observed that Singapore leaders demonstrated strength in areas of competencies such as decision making, and determining and executing business priorities (Busine, Till, and Dy-Liacco 2010). It is further observed that the decisions made and actions taken by the decision makers are characterized by a more cautious, risk-averse approach. In the current competitive and fast-paced work environment in Singapore, decision making is likely required at the individual, group, and organizational levels. The following seven deleterious conditions may be encountered during the decision-making process (Busine, Till, and Dy-Liacco 2010):

- Having limited or partially available information;
- Having incorrect information;
- Lacking access to domain knowledge to acquire essential or critical information;
- Having the domain knowledge but not the ability to obtain essential or critical information;
- Working under time constraint;
- Working under budget constraint;
- Having uncertain level of risk involved.

Considering these unfavorable conditions, the thesis research examines and highlights the existing group decision-making framework to improve the decision-making process. An essential element of decision making is to promote decisions characterized by good decision fitness. For the purpose of this research, the focus is placed on the organizational work environment in Singapore, including the for-profit private sector and the non-profit public sector.

The research undertakes a systems engineering approach that allows the identification and analysis of a group decision-making framework. The result is a framework that guides group decision making under cost and time constraints. The remaining five problems indicated by Busine, Till, and Dy-Liacco (2010) are recommended for future study.

B. DEFINITION OF GROUP DECISION MAKING

In a lecture conducted by Strategic Decisions Group (SDG) designated as DQ101 Introduction to Decision Quality, decisions are defined as choices that one can control (Strategic Decisions Group 2014). Magnus Gunnarsson describes group decision making as consisting of human beings who communicate interactively, attempting to reach a shared view concerning one or more future actions (2006). With a shared view, a group decision is made such that the members choose one of the available alternatives and create an obligation for themselves or others to act according to the selected choice. However, the intended outcome may not coincide with the produced result; thus, it is

important to differentiate the quality of decisions from the uncertainties that are factors with outcomes beyond one's control.

The DQ101 Introduction to Decision Quality lecture taught that there are different types of decisions, including strategic, significant, and quick decisions. Quick decisions are those that commonly occur and are decided on automatically at that moment. Significant decisions are those that are made less frequently than quick decisions and are decided on in hours. Strategic decisions are those that occur even less often than significant decisions and are decided in days, weeks, or months. Strategic decisions require a more complex and rigorous decision quality process compared to significant decisions. Decision makers who attempt to achieve decisions characterized by good fitness may encounter challenges arising from the analytical complexity of organizations or groups (Figure 1).

The following elements define diverse and complex organizations (Scott 2003).

- Social structures—defined as the patterned or regularized aspects of the relationship that exist among participants in an organization. Emphasis on the social structures allows the decision maker to see that much of any conflict is present in the organization or group is patterned, in the sense that it is built into the structure of relations between individuals and groups and not due to innately aggressive individual participants.
- Participants or Social Actors—defined as individuals that contribute to the organization and receive a variety of inducements in return. It is essential to recognize that their energy, ideas, conformity, and non-conformity constitute and shape the structure of the organization and carry on its functions. Without the ongoing participation of the participants in the process of making a group decision, there will be no group or any decision made.
- Goals—defined to be the desired ends that participants try to achieve through performance of certain tasks. Goals constitute a central point of reference for the participants and are indispensable to the understanding of an organization or a group doing the decision making.
- Technology—defined as the combination of the physical with the intellectual or knowledge processes in which some form of material is transformed into outputs. Alternatively, technology can be defined as the branch of knowledge that deals with mechanical and industrial arts, applied sciences and engineering, or a combination of the ways in which participants provide themselves with the material objects and the services of their civilization (Blanchard & Fabrycky 2011). The technology of an

organization can be partially embedded in machines and mechanical equipment and comprises the technical knowledge and skills of participants. The technology provides the mechanism that facilitates the transformation of inputs to outputs during the process of decision making and the execution of decision.

- Environment—defined as everything that is outside the boundaries of an organization, including physical, technological, cultural, and social environment. The environment has pervasive influence on the forms and operations of an organization.

Organizational complexity results from conflict among many parties, including the differences between individuals or organizations (groups) that may cause conflict. The DQ101 Introduction to Decision Quality lecture explained the potential differences, including the following:

- Personal values, desires, and motivation;
These emotions result in biasness during process of decision-making.
- Initial conviction;
This conviction results in having an inaccurate perspective of the decision situation.
- Fundamental frames;
These frames result in having an inaccurate perspective of the decision situation.
- Personalities and competencies;
These traits and attributes affect the disposition of the group decision process.
- Degrees of power and availability of resources;
This power and access to power result in the limitation and constraints of the decision situations.

Any one of these factors could encumber positive group dynamics that may hinder the process of decision making.

The DQ101 Introduction to Decision Quality lecture taught that analytical complexities may result from the following factors:

- Uncertainty about the future,
- Dynamics and available possibilities,
- Interdependent and influential variables,

- Availability of alternatives,
- Interrelated decision criteria,
- Multiple competitors.

The interdependent and influential variables and awareness of multiple competitors influence the framing of the decision situation. The consideration of dynamic and available possibilities and the availability of alternatives allow the decision-making group to explore the solution space fully and to generate a comprehensive set of creative and practicable alternatives. Uncertainty about the future requires the use of logically correct reasoning or decision logic to analyze the collected data and generate the essential information. The list of interrelated decision criteria can affect the tradeoff analysis that is part of the decision-making process. The combined impact from the aforementioned factors can affect the commitment of a group tasked with executing any plan which results from a group decision.

Because not all humans are predisposed to resolve matters of high analytical complexity by examining the components of such matters in simple terms, it is important that decision makers possess these analytical skills as part of their leadership qualities.

C. IMPACT OF GOOD DECISION FITNESS

Good decision fitness is achieved through systematic consideration of a comprehensive set of alternatives and by determining a selection that results in maximum satisfaction value to satisfy the needs of the stakeholders.

Lecture 3 of SI4021 Systems Engineering for Product Development (presented by Prof. Gary O. Langford at NPS in January 2014) explained that an effective decision captures the attention of higher management and motivates the team. Effective communication allows smooth execution of the decision by establishing an awareness of upcoming decisions among the team and making relevant data and information available. It is important to differentiate between data and information. Data can be a collection of facts, while information includes meaningful data. Additionally, the avoidance of “mega bias” further creates tremendous value potential that can be realized with the subsequent effective use of data or information.

D. APPROACH OF THESIS

A systems engineering approach was used in the process of establishing the thesis research. There are three main sections to the thesis, including a literature review, analysis, and a synthesis of ideas. First, reviews were conducted to relate the past and present literature on group decision making to the specifics of the research. Second, analysis was performed to determine the appropriate principles, theories, model, and approach for the group decision-making process. Third, there was a consolidation of the ideas to generate the method and framework for a group decision-making process to ensure risk management and good decision fitness under time and cost constraints.

II. LITERATURE REVIEW

A literature review was conducted to examine the past and present studies written in a wide variety of fields related to decision making. From business and social science to engineering, physics, and mathematics, decision making is an integral part of planning and carrying on with business. First, the positive and negative impacts to making a group decision were reviewed to isolate the best practices. Second, the types of problems that result in a decision situation were illustrated to identify the variables. Third, the six factors that affect a group decision and its decision fitness were identified to look for ways to improve decision making. Fourth, the decision phenomenon in Singapore resulting from globalization, emerging priorities of Singapore-based organizations, structural changes, and cultures were highlighted and contrasted with other nations.

A. DEFINITION OF GROUP AND GROUP DECISION MAKING

A group consists of two or more people (Bright 2010), while group decision making consists of human beings who communicate interactively, attempting to reach a shared view concerning one or more future actions (Gunnarsson 2006). In addition, Gunnarsson stated, “with a shared view, a group decision is made such that the members choose one of the available alternatives and create an obligation for themselves or others to act according to the selected choice.” However, the intended outcome may not coincide with the produced result.

The following decision-making techniques were introduced by Bright (2010).

- One person making the decision—usually the leader of the group.

Figure 2 shows the model of how a single decision maker makes the final decision on behalf of a group. DM represents the decision maker while F1 to F5 represent the participants from the various functions. While the functional participants are there to influence the decision, there is role differentiation within the decision-making group. An organization with a highly centralized system of decision making restricts the scope of discretion by individual functional participants in influencing the decision (Scott 2003). In addition, with differentiated roles within the decision-making group, disagreements and conflicts are more likely to develop and

be seen. Disagreements and conflicts affect the coordination and integration of information that are crucial for decision making.

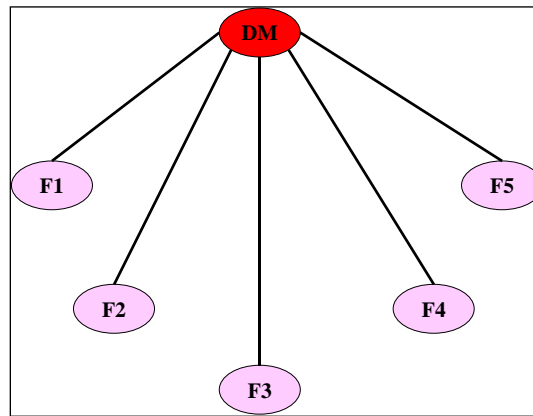


Figure 2. Model of one person making the group decision.

- Majority opinions determine the decisions. In the majority-rule situation, a decision can be made once a majority of the members within a group agree (Mohammed and Ringseis 2001).

Figure 3 shows the model of majority rule in a group decision making.

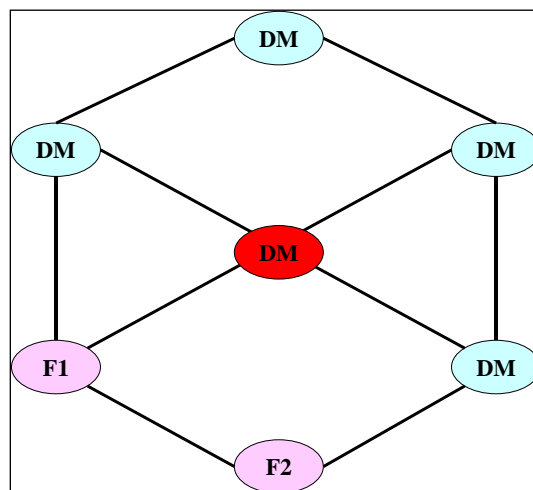


Figure 3. Model of majority-rule in decision making.

- The group reaches a consensus (unanimous rule) whereby it requires all members in a group to agree before a decision can occur. This is more likely to occur in a group where members share common objectives, have

equal status, encourage balanced participation, and are not steadfast in their opinions (Ellis and Fisher 1994).

Figure 4 shows the model of achieving 100 percent consensus from all participants in a group decision making. All participants have their fair share of authority and responsibility to give their consensus to the final group decision. This allows each participant to feel satisfaction and his or her importance to the group (Gunnarsson 2006).

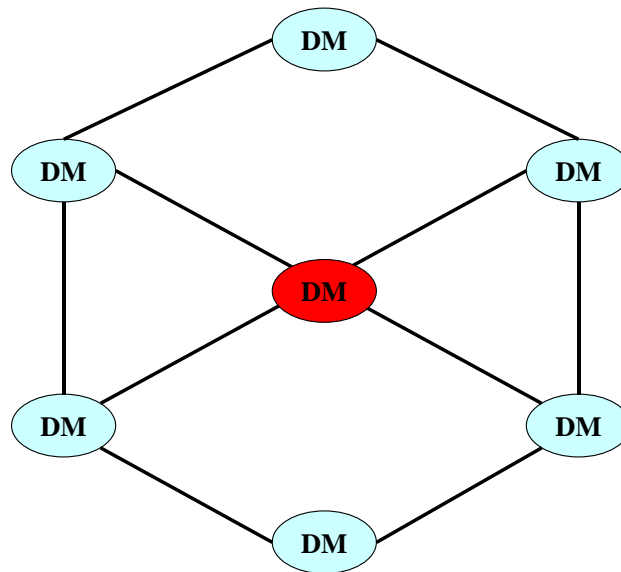


Figure 4. Model of achieving 100 percent consensus in a group decision.

Furthermore, research has demonstrated that cognitive consensus impacts group unity and performance (Gunnarsson 2006). Cognitive consensus is the “similarity among group members regarding how key issues are defined and conceptualized” (Mohammed and Ringseis 2001). Mohammed and Ringseis determined that the group using unanimous rule had higher cognitive consensus compared to the majority-rule group. With a higher level of cognitive consensus, a shared mental model is created among the group.

B. IMPORTANCE AND IMPACT OF A GROUP DECISION

A group can create a shared mental model or team mind (Bright 2010), whereas in a group, the decision-making process consists of different functional members, differing opinions, open exchange of ideas, and a way to select among the alternatives (Bright

2010). The interaction that occurs within a group and results in a collaborative decision is found to be better than one made by an individual (McClung 2002). In a study made on the decision-making characteristics of a recreational winter backcountry group of Canadian avalanche experts when making a decision of where to travel and ride in avalanche terrain, it was found that collaborative group decision making improved the overall judgment and decision choices (Adams 2005). The decision-making process involves communication that encourages the exchange of ideas and observations and vigorous discussion among the members. With that acceptance of fairness, having a group of people involved in the making of a group decision allows interaction among the members and the occurrence of communication. In addition, having 100 percent consensus in the group is the organizing element during a group decision-making process and is the “crux of the task and social dimensions of all groups” (Fisher 1980).

Critical thinking is a way of analyzing situations and issues that encourages investigation, discovery, and invention to look at problems and solutions from many perspectives. Critical thinking is defined as disciplined, self-directed thinking that displays a mastery of intellectual skills and abilities (Joseph 2013). In addition, critical thinking involves three tightly coupled activities: it analyzes thinking; it evaluates thinking; and it improves thinking (Joseph 2013). Critical thinking equips the decision group with the ability to look continually for order, system, and interrelationships in the decision situation (Paul, Niewoehner, and Elder 2007). Critical thinking is found to be important for presenting and evaluating alternatives. Critical thinking results in sound judgment when making decisions. According to Michael O’Rourke (2005), critical thinking characterizes good decisions by ten factors. These factors are quoted as follows (O’Rourke 2005):

- Classification: What category does an aspect of an option or the result of a particular inspection fall into? How do these categories relate to one another?
- Comparison: How do the various elements compare to one another? How does the element in question compare to the ideal described by the applied standard? How do the results of the inspections relate to one another?
- Discrimination: What are the parts (spatial, temporal, etc.) of the option? What is the structure that binds these parts together?

- Elaboration: How can the description of an aspect of an option or inspection be increased in detail without undermining its character?
- Experimentation: Can the options be tested in different contexts to establish that they are in fact relevant? This includes both physical experimentation and thought experimentation.
- Inference: What follows from the explicit aspects of the option or inspection? That is, what do they imply? Are these implied aspects relevant to the evaluation?
- Ordering: How should the results of inspection be ordered—should one be given logical or thematic or political ... prominence over others?
- Prediction: What should follow if this option is believed or acted upon? (This forms a part of the thought experimentation that often figures into inspection of options, experimentation designed to determine the effects of a belief or course of action. Identification of these effects will often influence the results of an inspection.)
- Restructuring: Can the analysis be accomplished in a different way? Is there a different and preferable way to synthesize the results of inspection into an acceptable result?
- Verification: Has the analysis been conducted correctly? The inspection? The synthesis?

According to the second lecture of SI3400 Fundamentals of Engineering Project Management taught at the Naval Postgraduate School (Langford 2009), a better decision quality is achieved by the decision maker(s) when there is presence of alternative input from a group of opinionated individuals compared to the input of only one individual.

1. Impact of a Group Decision

Dolly Chugh and Max Bazerman investigated the implications of descriptive theories in psychological context to describe the behaviors of individuals, groups, and organizations when making group decisions (Chugh and Bazerman, 2005). The impact of behaviors on a group decision can establish biases and sway the decision outcomes. These authors suggested that awareness is bounded because participants in the decision process either fail to see or ignore information that is readily available (Bazerman and Chugh 2005).

Bounded awareness is the limited set of information that a group uses during discussion to make a decision (Bazerman 2006). While it is crucial for individuals to share information, group discussion can provide additional information that aids in the completeness, identification of biases in information, and thoroughness of discussion regarding decision alternatives of another individual (Stasser and Titus 1985).

Potential errors exist in the decisions made by a group. A group can make poor decisions, especially when group dynamics are undesirable and decision-making errors are related to assumptions (Bright 2010). Poor assumptions are one of the many reasons for poor decision quality. Members of the group may have failed to challenge the perspective of each other with the assumption that they share the same opinions and know each other's beliefs. This phenomenon is known as *Groupthink*, a well-known error in which the ability of a group to maintain rational judgment is compromised to preserve group cohesion. In the Groupthink phenomenon, participants are engaged in a mode of thinking whereby they are deeply involved in a cohesive in-group that causes participants to strive for unanimity and override their motivation to realistically appraise alternative courses of action (Quizlet 2014). As a result, Groupthink has disadvantages which include incomplete survey of alternatives, poor information generation, selective biases in processing information at hand, failure to examine risks of preferred choice, and failure to work out contingency plans. Thus, Groupthink is undesirable for high-quality decisions.

C. TYPES OF PROBLEMS

The following subsections examine the components and classification of problems. Defining a problem serves to focus efforts and resources on a particular aspect of a potentially large number of concerns. Lack of focus dilutes work on finding a set of alternative solutions.

1. Components of Problems

A problem has been thought of as the gap between the current undesirable situation and a future desirable situation (Joseph 2013). However, from a systems engineering perspective, the difference between “want” and “need” indicates that a

problem is not defined in such a way. The definition of “need” and “want” is as follows (Langford 2012, 364–373):

Need is something you must believe will solve the problem, is possible, is affordable, can be provided when desired, and does not cause another problem of such significance that offsets the benefit of solving the original problem. A want is something that will solve the problem, but is not necessarily possible, affordable, deliverable, or acceptable. A need is absolute and unconditional. A want is a desire that is unfulfilled.

Once the problem is accurately defined, group decisions can be made to create the solution system and to remedy the undesirable situation. Problems contain the following six components (Ackoff 1978).

1. The decision maker is the one that directly or indirectly faces the problem. The decision maker may consist of a group of people led by a leader or an individual.
2. The control variables are the aspects of the problem that can be controlled by the decision maker.
3. The uncontrolled variables are the environmental aspects of the problem that cannot be controlled by the decision maker.
4. Constraints are the limiting boundary imposed from within or without on the possible values of the controlled or uncontrolled variables.
5. In a broader context, constraints are results of boundary condition. Constraints are also seen as the initial established conditions of allocations that can be changed, however, vicissitudinous. Constraints are flexible within the overall limitations set (Langford 2012).
6. The *possible outcomes* are the results produced jointly by the choice of the decision maker and the uncontrolled variable. The uncontrolled variables may give rise to undesirable outcomes that are unanticipated properties of the decision

2. Classification of Problems

Following are several methods for classifying problems (Joseph 2013).

- The level of difficulty of the problem—here are four different categories of problems with an increasing order of difficulty, including easy, medium, ugly, and hard. Easy problems are those that can be solved in a short time with little thought. Medium problems are those that are solved after some consideration, without too much difficulty, and improve with practice. Ugly problems are those that require some time to solve iteratively. Hard problems are those that usually involve dealing with one

or more unknowns. They require further research, learning, and iteration to solve.

- Type of problem: Research or Intervention—research problems are evident when the phenomenon of the undesirable situation cannot be explained due to absence of a particular area of knowledge. With that, there is a need to gain the needed knowledge through, for instance, scientific method. Intervention problems are evident when a current real-world undesirable situation needs to be changed and transitions progressively into the desirable situation. It happens potentially due to a lack of some desirable functionality that needs to be created, or the presence of some undesirable functionality that needs to be eliminated.
- Structure of the problems—from the continuum perspective, problems lie on a continuum range varying from “well-structured” to “ill-structured.” Well-structured problems are ones where the current undesirable situation and future desirable situation are accurately identified. The problem with closed questions or open questions will generally have a single solution or multiple solutions, respectively. Ill-structured problems are messy problems that contain current undesirable situations and future desirable situations, and are not clearly defined. Wicked problems are extremely ill-structured problems that cannot be easily defined and are difficult to reach an agreement from all the stakeholders for resolution. These problems often contain strong morals, or political and professional dimensions.
- Complexity of the problem—the complexity of the problem is influenced by the number of involved issues, functions, and variables; the degree of interdependency and relationship among the variables, and the stability among the properties of the problem over time.

A two-dimensional problem classification matrix involving complexity and level of difficulty of the problem is shown in Figure 5. The vertical axis reflects the complexity of the problem, and it ranges from non-complex through complex well-structured problems, to complex ill-structured problems and wicked problems. The horizontal axis reflects how complicated the problem is and the level of difficulty of the problem. This scale ranges from easy through medium, to ugly and hard problems. From Figure 5, it can be seen that wicked and ill-structured problems have no solutions. To achieve decision fitness, it is important that the problem is framed accurately for the resolution of the decision situation.

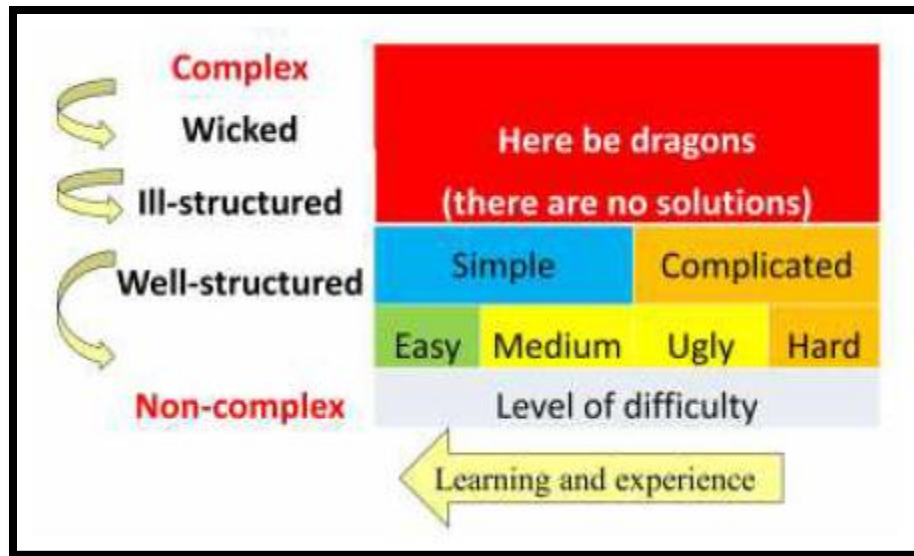


Figure 5. Problem classification matrix (from Joseph 2013).

D. FACTORS AFFECTING GROUP DECISIONS

Decision-making characteristics are the aspects of decision making that include *communication, decision-making processes, leadership, human factors, organizational cultures, and decision quality elements* (Bright 2010). These characteristics translate to factors that will affect the quality of a decision and form the fundamental problem to achieving good decision fitness.

1. Decision Fitness

The lectures in DQ101 Introduction to Decision Quality stated that to measure and achieve quality in the overall decision, there are six quality elements that must be considered and fulfilled up to a maximum scale of 100 percent. Following are the six quality elements that contribute to decision fitness (Strategic Decisions Group 2014).

a. *Appropriate Frame*

The element of having appropriate frame ensures the group is working on the right decision with crystal-clear purpose, defined scope, and conscious perspective. At the same time, there is an involvement with others in the group through interactions that support this frame. Additionally, it is important that the group has the means to assess a

variety of information that may include uncertainty. Then, uncertainty may be incorporated into the appropriate frame.

b. Creative, Doable Alternatives

The group may stretch their creativity to determine a comprehensive set of significantly different, compelling, and feasible alternatives. The “right” brain will facilitate the creativity required for brainstorming, while the “left” brain will facilitate the systematic approach, for instance, in the form of a strategy table. A strategy table identifies the purpose and other key decisions by presenting the set of alternative solutions in a logical way to facilitate analysis and evaluation. The benefit of a strategy table is to formulate all possible combinations of strategies, regardless of their logic or sensibility. The multi-dimensional aspects of such a variety of combinations of strategies often trigger discussion that leads to a set of creative alternative solutions.

c. Meaningful and Reliable Information

Information serves two primary needs for decision making, namely expansive and reductive. First, information expands the frame, generates new alternatives, and aids consideration of new models and relationships. Second, information reduces future uncertainty and facilitates Bayesian Revision that allows systematic revisions of information in light of new learning. While information needs to be forward-looking and relevant, it contains a certain degree of uncertainty. For instance, one tends to take shortcuts when making significant decisions, which makes it essential to fill the information gaps.

Applying information from the past can assist in understanding present and forecasting future information. Such understandings and forecasts, are often are used to form a “tree” of possibilities. Possibilities coupled with probabilities help to describe the likelihood of future events. Forecasts are generated by many sources, such as engaging in macro forecasting services, conducting crowd sourcing to solicit alternative futures, traditional market research, seeking expert judgments or using the Delphi method to identify problems, and performing predictive analytical modeling.

Because human nature tends to cause an individual to drag problems into one's comfort zone, deterministic information is assumed and resolutions are achieved along the way. Perceptions are often distorted, and rationale may lead to a hindsight bias. Often we are over-confident and underestimate uncertainty, which may result in misinterpretation of the big picture. Therefore, it is important for organizations to identify relevant and important information. Decision trees may serve as power tools to reason and accomplish clarity regarding the organization of important factors of a decision in chronological sequence.

d. Clear Values and Tradeoffs

During decision making, a focus should be on value creation and clear identification of decision criteria that reflect objectives of the key stakeholders. The identified decision criteria will facilitate the analysis of alternatives that involve consistent and conscious tradeoffs. Both clarity and communication are important components when defining values to the required group decision and conduct of tradeoff analysis.

e. Logically Correct Reasoning

Setting forth the correct decision logic allows uncertainty and complexity to be addressed. Decision logic is the communicable relationship between cause and effect that show causal influence on the factors important to a decision. Decision logic should not include personal instinct or intuition. Decision logic plays an important role in the nature of humans who are not always capable of manipulating uncertainties. Correct decision logic results in clarity of choice. While logic is not subjective, it is recognized that input to the reasoning process is subjective. This subjectivity is due to the limited abilities and potential bias of individuals. Potential bias will be discussed in "Fourth Factor: Human Factor," in the following section.

Having correct decision reasoning will systematically focus on alternatives that present the most desirable outcome to satisfy the objective of the key stakeholders.

f. Commitment to Action

Group decisions should be completed with commitment to effective action. Commitment to execution should be built up progressively during the decision-making effort. Progressive buildup will create execution readiness that provides the decision maker with the answer – with this, I can do that.

All of these six elements are equally important in contributing to the overall decision quality. The quality of decision is only as good as the weakest link. The goal is to attain 100 percent for each element. A 100 percent quality decision is achieved when additional effort is not required to improve the quality.

2. Factors

As previously mentioned, decision-making characteristics are factors that will affect the quality of decision making (Bright 2010). Bright identifies the following five factors of quality decision making.

a. First Factor: Communication

The first factor that affects the quality of decision making is *communication* within a group in an organization. The effectiveness of communication can be divided into intrapersonal and interpersonal attributes. Intrapersonal attributes are those from within and include the attitude of an individual toward the group, interaction, creativity, criticism, and honesty. Interpersonal attributes support the interaction of an individual with other members of the group. The interaction includes active verbal participation, communicative skills, supportive communication, and responsiveness to others.

In terms of communication, two of the most important skills that catalyze engagement within a group are critical listening and questioning. It helps to engage members of the group, figure out what they are thinking, establish a productive environment, and encourage dialogue. Critical listening is necessary as it intellectually engages the listener. The listener analyzes, interprets, and questions what the speaker is saying. At the same time, the listener performs self-questioning. The four strategies for listening critically are to eliminate distractions, listen for concepts and ideas, organize

what is being heard, and evaluate what is heard. Critical questioning requires an individual to question another individual for further clarification, or to justify what the current speaker is saying. Critical questioning is not meant to be negative or critical, but to allow deeper understanding and expand the quality of discussion within the group members. The three strategies for critical questioning include requesting clarification, asking analytical and tough questions, and asking group members to expand their thoughts.

Studies were made by Bright (2010) to identify four communication characteristics that differentiated effective and ineffective groups. The four communication characteristics of an affective group include:

1. Members of a group strongly evaluated the legitimacy of the opinions and assumptions made by other members within the same group.
2. Group members evaluated a comprehensive set of possible decision alternatives.
3. Group members utilized accurate and intelligent premises for discussion.
4. Influential members of a group facilitate and encouraged open communication.

Effective communication aids the group in processing information, exchanging opinions, examining ideas, and reaching consensus. However, a group that is engaged in continuous communication and agreement should use caution when there are signs of instability in the group dynamics. Bright 2010 suggested that the leader of the group adheres to the formalized decision process with various checkpoints that allow re-evaluation and decision making at each check point.

b. Second Factor: Process of Decision Making

The second factor that affects the quality of decision making is the *process of decision making*. Group decision making has been described as an “information-processing process.” Following are six major steps in the information-processing process where information is filtered.

(1) Attention or Perception

Attention or perception helps to provide a basis for a mental model through which an individual attends and perceives information. A group can consist of members sharing the same mental model or divergent mental models. The latter can result in potential misunderstanding during process of decision making.

(2) Acquisition

Acquisition is the most complex step that requires the group to acquire information for subsequent processing. Efficient acquisition of information requires a near-complete listing of the tasks that the group must address; an agreement on the strategies that will be used to search for additional information and clarifying data; access to the necessary technologies to support the group's work, and the means to identify and organize what remains to be acquired.

(3) Encoding

Encoding reflects the information held by each individual in their group as represented by the entirety of the group's information – their shared knowledge. A group encoding process results in a shared mental model and an understanding of the aspects of the combined decision.

(4) Storage

Storage consists of the knowledge that is captured in group memory. Information can be disseminated readily to relevant individuals in the group. Depending on the quality of collaboration required for group memory, process losses can occur, which cause potential information loss. However, information loss can be avoided by having highly defined roles and experience together as a group.

(5) Retrieval of Information

Retrieval of information in a group is more enhanced as compared to a single individual. This enhancement within a group can help to identify correct or faulty retrieval of information. Errors can occur when an individual retrieves information based on a mental model that does not match that of the group.

(6) Judgment or Decision

Judgment or decision is the choice that the group makes because of individual and group's information processing.

c. Third Factor: Leadership

The third factor that affects the quality of the decision making is *leadership* of the person in the group performing decision making. Studies have been conducted to determine how selection of leaders will impact the group performance, especially in terms of quality of decision making (Bright 2010).

It was found that randomly selected leaders produced superior group performance over groups with systematically selected leaders or groups with no appointed leader. However, randomly selecting leaders should be done with caution. The literature suggests that the use of randomly selected leaders is appropriate only when the group contains the following factors.

- Has a clearly defined common goal.
- Is capable of behaving in a relatively democratic manner in terms of decision making and sharing of responsibility.
- Exhibits the presence of a reasonably strong sense of shared social identity in the absence of an appointed leader.

Further studies were made to determine the influence of how leaders are selected, as well as the quality of a leader's information sharing. They concluded that a systematically selected leader would result in a higher quality of decisions when the leader possessed fluent information. The disadvantage to a group led by a systematically selected leader is that there is a lower level of group cohesion (Bright 2010).

d. Fourth Factor: Human Factors

The fourth factor that affects the quality of decision making is related to *human factors*. Human factors are conditions of thinking errors that affect the ability of people to accurately assess the actual situation. The majority of identified human factors affect thinking and decision making. For instance, onset of fatigue may cause an individual to miss important details. In particular, it was found that there are three human factors that

may negatively influence individual members of the group and subsequent decision making (Adams 2005). The three human factors are inadequate communication, being influenced by others, and resistance to different opinions. An expanded list of twenty-one human factors that have varying levels of influence are identified Figure 6.

<i>Human Factors in the Literature</i>					
Human Factors	Adams, 2005a	McClung, 2002a	Atkins, 2000	Fredston & Fesler, 1999	Fredston, Fesler, & Tremper, 1994
Ego and attitude			x	x	x
Poor communication	x		x		x
Believing what one wants to believe	x				x
Indecision and complacency			x	x	
Peer pressure	x			x	
Thinking if have good skiing ability, then have good avalanche safety skills				x	x
Thinking there is safety in numbers				x	x
Fatigue				x	
Group management			x		
Haste				x	
Incorrect assumptions				x	
Laziness				x	
Letting one's guard down on a sunny day					x
Miscalculating consequences				x	
Not respecting power of mountains and nature					x
Overconfidence			x		
Perception vs. reality		x			
Poor planning				x	
Risk-taking propensity		x			
Summit fever				x	
Testosterone influencing behavior					x

Figure 6. Human factors in the literature (from Bright 2010).

e. Fifth Factor: Heuristics

Heuristics are mental shortcuts or guiding principles that an individual uses unconsciously to guide her or his decisions. These principles often affect the quality of

group decision making. Figure 7 shows an overview of the heuristics identified as potential influences on the decisions of backcountry recreationists. The presence of any of the identified heuristics has a negative impact on communication and the process of decision making. In particular, both “acceptance” and “expert halo” directly impact decision making.

<i>Heuristics with Descriptions and Sources</i>		
Heuristic	Description	Literature
Familiarity	<ul style="list-style-type: none"> Being familiar with a slope and assuming it is safe because it has been skied in the past and not avalanched. 	McCammon, 2004; Tremper, 2008.
Consistency/commitment	<ul style="list-style-type: none"> Believing a behavior is correct because it is consistent with a prior commitment. Not changing a plan to ski a particular slope regardless of clues indicating danger. Being committed to an identity, such as risk-taker, that influences behavior. 	McCammon, 2004; McCammon, 2002; Tremper, 2008.
Acceptance	<ul style="list-style-type: none"> Participating in a behavior (such as skiing a risky slope) that will possibly gain attention and acceptance from others. Going along with the group and not speaking up even when concerned so as maintain acceptance of the group. 	McCammon, 2004; Tremper, 2008.
Expert halo	<ul style="list-style-type: none"> Relying on an informal leader as an expert when she/he does not have adequate knowledge and skills. 	McCammon, 2004; Tremper, 2008.
Social facilitation	<ul style="list-style-type: none"> Taking more risks after having met another group. 	McCammon, 2004.
Scarcity/competition	<ul style="list-style-type: none"> Being motivated to reach a particular slope so as to be the first to ski scarce, untracked powder. 	McCammon, 2004; Tremper, 2008.
Social proof/herding instinct	<ul style="list-style-type: none"> Looking to others for behavior cues. Taking more risks in a group. 	Tremper, 2008.

Figure 7. Heuristics with indication of respective literature sources (from Bright 2010).

Heuristics of acceptance happen when an individual has the tendency to go along with the crowd with the intention to gain and maintain acceptance from her or his peers.

The process of group decision making becomes undesirable when members of the group fail to voice their concern. Heuristics of expert halo occur when a positive impression of an informal leader within the group leads the group to ascribe certain skills to that person that he may not have. The resulting impression of the leadership could be built on the basis of knowledge, experience, seniority, or assertiveness. This structure may be based on the false assumption that the leader possesses the ability to lead the group in effective group decision making. The heuristic of “herding instinct” motivates an individual to make riskier decisions when they are in group. The level of risk taken increases as the size of the group increases. The phenomenon is attributed largely to the decrease in the ability of an individual to perceive reality as the number of individuals in the group increases. Following this heuristic can cause a breakdown in communication of the group (Bright 2010).

From the lectures in DQ101 Introduction to Decision Quality, a study by SDG reveals that the following six categories of biases affect decision making when human factors and heuristics are applied:

- Automatic associations—associations done subconsciously due to experiences of a similar nature.
- Protection of mindset—mindset is protected by having selective attention to things that confirm what one already believes. This includes selective status quo bias and selective memory.
- Social influences—external influences that include wanting to conform to the majority and being persuaded by peer group pressure.
- Habits and personality—bias occurs when the problem is dragged into one’s comfort zone and is being solved habitually and routinely as opposed to solving the real problem.
- Faculty reasoning—logic that the mind infers or deduces that is not rational. It may be due to certain degrees of uncertainty and involved complexity.
- Relative thinking—difference between perception of an individual and reality.

f. Sixth Factor: Organizational Culture

The sixth factor that affects the quality of decision making is *organizational culture* (Dale 2012). According to Schein (1992), the culture of a group is defined as

A pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems.

According to the study made by Dale (2012) on the perception of organizational culture, it was observed that culture is developed through a socialization process experienced by employees as they learn to appreciate the shared values, practices, and acceptable behaviors of an organization. Thus, an organizational culture is reflective of what is valued, the dominant leadership styles applied, the language and symbols used, the procedures and routines adopted, and the definitions of success that are standards for the organization. An organizational culture can be seen as the personality of an organization and is somewhat analogous to that of an individual. This view of similarity includes values, beliefs, practices, socialization processes, and acceptable behaviors.

Dale (2012) identified the four different organizational cultural types as follows:

- Clan
- Adhocracy
- Market
- Hierarchy

A Competing Values Framework is developed to represent the required leadership, effectiveness, and organizational theory that result in the aforementioned four organizational cultural types. In the study, it was stated that all four cultural types are necessary for every organization (Dale 2012). Both Clan and Adhocracy cultures emphasize the creation of a culture that encourages flexibility and discretion for the organization. These cultures are more people-centric, as opposed to business task-centric, as they focus on the development of human resources and talents. Some of the important traits of Clan culture are teamwork, inclusion empowerment (translating to flexibility and discretion), employee orientation, and training programs. To bring about organizational change, identifying management competencies is important when assessing or hiring leaders and managers that possess these leadership and management skills, abilities, and

styles. Thus, an organizational culture will indirectly affect the quality of the decision making.

E. HIGHLIGHTING AND CONTRASTING THE ORGANIZATIONAL ENVIRONMENT IN SINGAPORE

The following four areas highlight the contributing factors that result in the decision phenomenon in Singapore. These areas include globalization, emerging priorities, structural change, and culture. The understanding of the four contributors creates an awareness of how a typical Singapore-based organization makes a group decision and was influential in developing the method and group decision-making framework generated in this thesis.

1. Globalization

According to the trend research done by DDI (Busine,Till, and Dy-Liacco 2010), with the constantly changing global and local business landscape, Singapore continues to adapt and grow relentlessly and “exponentially” to pursue an innovative- and knowledge-based economy to remain competitive in world markets. This effective policy for growth helps to deal with the significant changes in the expectations of key stakeholders in a Singapore organization. Key stakeholders may include customers, shareholders, and employees (Busine, Till, and Dy-Liacco 2010). In addition, the increase in the offshoring of knowledge- and service-based activities has well-placed Singapore as a regional hub to function as a regional and global center for the transfer of goods, services, and knowledge. Facing fierce growth competition from China, India, and other Southeast Asian economies, an increasing number of Singaporeans are seeking opportunities to build their portfolio of global knowledge and experience. It is widely recognized as being important in such a diverse, competitive environment to have the ability to think globally and work across different cultures and countries.

With ultra-rapid technological advancements in the Internet and information technology, the world has become much more interconnected, and technology has revolutionized the work process exponentially. Aided by the dissolution of the traditional barriers of time and distance, the stakeholders have more visibility and accessibility to

required information. Consequentially, organizations must keep up with the management of big data that will aid decision making. Senior leaders need to take a holistic view of the global business landscape to understand the risk and leverage on both local and global opportunities.

2. Emerging Priorities of Singapore-Based Organizations

In the research by DDI (Busine, Till, and Dy-Liacco 2010), it was observed that organizations in Singapore are shifting toward a culture of creativity and innovation, service quality, and risk taking. The key business priorities that are shared by both Singapore and other worldwide organizations include:

- Accelerating revenue growth that can sustain both locally and globally,
- Driving operations efficiently in all business activities,
- Cultivating a customer-focused culture to ensure customer satisfaction,
- Fostering a culture that catalyzes innovative ideas and products to create an unique value proposition, and
- Driving and maximizing profitability.

Compared to other countries in the world, in the author's opinion, Singapore is perhaps more acutely aware of its strengths and limitations. With a conscious surveillance on both short- and long-term trends, Singapore constantly assesses and adjusts its role in the global economy. In doing that, Singapore has continually shown its resilience and adaptability. Based on the study conducted by DDI (Busine, Till, and Dy-Liacco 2010), it is observed that leaders in Singapore have a tendency to be more prudent as compared to their respective global counterparts of multi-national organizations. The stability of the country in a high-technology environment requires progressive growth rates and satisfaction of its citizens' needs. In addition, leaders in Singapore are likely to avoid aggressive pursuit of new ideas and approaches that contain elements of risk. Risk-taking is a recent characteristic of many organizations in Singapore, at odds with the traditional observation as reported in the DDI 2010 study. Unfortunately, some of the leaders in Singapore often appear to resist change, which is a natural response to risk. It is observed that leaders in Singapore often work independently and place practical emphasis on predictable solutions.

With the identified key business priorities in Singapore required for organization growth, change, and innovation for the next three years, leaders are expected to deal with five challenges that are identified as follows (Busine, Till, and Dy-Liacco 2010):

- Drive revenue growth through local and global expansion,
- Drive operational efficiency and profitability,
- Cultivate innovation,
- Enhance customer relationships and focus, and
- Engage and inspire people.

Following are the top three most critical leadership skills required of the leaders (in descending order of importance):

- Driving and managing change due to changing global business landscape,
- Identifying and developing future talent, and
- Coaching and developing others.

For each of the identified challenges, group decision making is one of the tasks that leaders need to manage. Under time and cost constraints, technology has assisted leaders with the ability to handle and analyze big data. Thus, the ability to make good decisions in the presence of time and cost constraints forms the backbone of the identified top three leadership skills.

3. Structural Change in Organizations

The varying international, political, and economic forces in Singapore and other developed nations have created challenges for organizations. The greatest challenge is to find, manage, and retain suitably skilled and capable talent (Busine, Till, and Dy-Liacco 2010). Similar to other developed nations, Singapore continues to face a significant shortage of skilled workers that seems unlikely to abate in the near future.

The generation of baby-boomers is in their sixties and will be retiring from the workforce over the next ten years (Busine, Till, and Dy-Liacco 2010). Along with the study done by DDI (as discussed earlier), these retirements will cause a massive gap in the labor pool and loss of significant organizational knowledge and skills. In addition, it is estimated that by 2015, 29 percent of the workforce will be made up of workers above

the age of 50 years old. By 2050, nearly 40 percent of the population in Singapore will be over the age of 60. As of October 2012, Singapore was ranked 24th in the world for rapidly aging population (Bloomberg 2014).

The next younger cohort consists of the Generation X and Generation Y populations, respectively older and younger. The Generation X population is highly sought after, as they are more educated and knowledgeable in both technical and scientific fields. The competition to secure talented Generation X members is intensified by the growth of the Chinese economy and other developed nations. There are a plethora of travel and expatriate experiences being offered to the mobile group of Generation X (Busine, Till, and Dy-Liacco 2010). On the other hand, the younger Generation Y seems less interested in “climbing up the corporate ladder” as compared to Generation X, which makes it difficult for organizations to retain talent from that group. Both Generation X and Generation Y possess up-to-date technical knowledge, attain greater mobility with their job, and are more open minded, and entrepreneurial. With that, Generation X appears to be able to make better decisions as compared to Generation Y, as Generation X has more years of experience and more education. The open-minded characteristic of Generation X is favorable as it avoids biases during decision making.

4. Cultures

Five dimensions measure a culture in an organization: 1) Power Distance; 2) Uncertainty Avoidance; 3) Individualism-Collectivism; 4) Masculinity-Femininity; and 5) Long-term-Short-term orientation (Hofstede and Hofstede 2005). Long-term-short-term orientation is also referred to as Confucian Dynamism. According to the study carried out by Hofstede, Singapore scored 74, 8, 20, 48, and 48 for Power Distance, Uncertainty Avoidance, Individualism-Collectivism, Masculinity-Femininity, and Confucian Dynamism, respectively. For the context of Singapore, the value of five dimensions and its implications are further examined.

Power distance is defined as the extent to which the less powerful members of institutions and organizations within a country expect and accept that the power is distributed unequally (Hofstede and Hofstede 2005). In Singapore, the presence of a large

power distance (value: 74) is observed. The emotional distance between subordinates and their bosses is large; therefore, subordinates are unlikely to approach and contradict their bosses directly. The organizations in Singapore are also observed to have many hierarchical levels. This multi-level structure affects the group decision-making process, as there may be a smaller contribution of different opinions or solutions to ensure a comprehensive exploration of solution space.

Uncertainty avoidance is defined as the extent to which the members of a culture feel threatened by ambiguous or unknown situations (Hofstede and Hofstede 2005). Alternatively, uncertainty avoidance can be seen as the degree to which members of an organization are able to cope with the future uncertainty without experiencing undue stress. In Singapore, the presence of a weak uncertainty avoidance (value: 8) is observed. The organizations in Singapore are observed to be risk taking in a social sense, tolerant of differing behaviors and opinions, flexible, and because there is a relatively low degree of structure, few rules and promotions are based on merit. As a result, there is a positive impact on the group decision-making process due to a weak uncertainty avoidance that favors the contribution of differing opinions or alternatives.

Individualism pertains to societies in which the ties between individuals are loose and everyone is expected to look after herself or himself and the immediate family (Hofstede and Hofstede 2005). Collectivism pertains to societies in which people from birth onward are integrated into strong, cohesive in-groups, which continue to protect them throughout their lifetime in exchange for unquestioning loyalty. Singapore is observed to have a characteristic of collectivism (value: 20) in organizations. The organizations in Singapore tend to behave according to social norms to maintain social harmony among members of an in-group, or within decision groups in an organization. In-groups refer to family and friends. In organizations, there is an emphasis on the hierarchy within the group and regulation of behavior through group norms, resulting in positive impact to the group decision-making process, and emerging trust and respect in the interaction among the members of a decision group.

An organization is known as *masculine* when emotional gender roles are clearly distinct, and men are assertive, tough, and focused on material success. Whereas an

organization is known as *feminine* when women are modest, tender, and concerned with the quality of life (Hofstede and Hofstede 2005). An organization is also known as *feminine* when emotional gender roles overlap in which both men and women are supposed to be modest, tender, and concerned with the quality of life. Singapore is observed to have a balanced mix of characteristics of masculinity and femininity (value: 48). Thus, organizations in Singapore emphasize both career success and quality of life, resulting in a positive impact to the group decision-making process, with members maintaining a positive attitude throughout the process.

Long-term orientation (LTO) refers to the fostering of virtues oriented toward future rewards. The virtues of LTO include perseverance and thrift (Hofstede and Hofstede 2005). On the other hand, short-term orientation (STO) refers to the fostering of virtues related to the past and present (Hofstede and Hofstede, 2005). The virtues of STO include respect for tradition, preservation of “face,” and fulfilling social obligations. Singapore is observed to have long-term orientation (value: 48). In particular, the organizations in Singapore are observed to have respect for circumstances and show remarkable economic growth in the last decades of the twentieth century. This manifestation of respect could provide a positive influence to a group decision-making process as stability and virtuous behavior are achieved during the interaction. Harmony promotes and aids positive interaction during a group decision-making process.

F. DEFINITION OF LOW RISK

With the rapid change in technology, plus the inherent need to balance cost, technical performance, and schedule, an organization has to deal with uncertainty and risk involved with decisions made (Kerzner 2013). Risk is considered when there are consequences or impact or damage associated with the events emerging from the group decision made. The difference between risk and uncertainty is that specified probabilities can be assigned to occurrence of event under risk, but it is not possible to assign meaningful probabilities for uncertainty (Kerzner 2013).

Decision making in Singapore is premised on actions taken with managed risks. Risk is a structural property of interaction between physical and intellectual objects

(Langford 2012). As a result, risk is inherent in the interactions involving the enterprise, business, project, and people within an organization. Low risk occurs when there is a low probability of events happening or impending effects occurring in an organization. Risk management becomes an essential and constant process to an organization that seeks to mitigate the uncertainty that influences the achievement of objectives.

The definition of risk management is quoted from Kerzner (2013) as follows:

Risk management is the act or practice of dealing with risk. It includes planning for risk, identifying risks, analyzing risks, developing risk response strategies, and monitoring and controlling risks to determine how they have changed.

A proper risk management is proactive rather than reactive and positive rather negative and seeks to increase the probability of project success.

Hence, proper risk management will attempt to reduce the probability of an event occurring and/or the magnitude of its impact as well as increase the probability of project success.

According to the study made by DDI, decision makers in Singapore are likely to avoid aggressive pursuit of new ideas and approaches that involve high stakes or elements of risk (Busine, Till, and Dy-Liacco 2010). In addition, DDI observed that decision makers in Singapore resist change and favor an independent working style. In spite of these leanings of the decision maker towards practical and predictable solutions and outcomes, the concept of risk-taking may be encouraged by Generation X or Generation Y, depending on the events of the next several decades.

III. SCOPE

The goal of this study is to develop a framework that provides guidance to the process of making a group decision that ultimately results in the emergence of a good decision quality under time and cost constraints. To establish the proposed framework, this study undertakes a systems engineering approach that provides a systematic means of determining the needs of people or organizations that have a stake in the outcome of the work. However, the outcome of decisions that result from this process is not within the scope of this thesis.

A. CONTEXT

The situation in which the group decision making may take place is defined in the following sections.

1. Good Decision

A good decision is achieved through decision fitness (where scope/context of the decision situation is accurately identified). The outcome of the decision is not part of the thesis study. However, it is noted that the outcome has to be determined and measured for pre-determined time. The outcome may be desirable initially. And, the outcome may evolve with time and become undesirable.

2. Manage Risk

Risk is managed through mitigation of identified risks during the early stages of decision making. Gary O. Langford (2012, 367) has explained that “risk is inherent in the interactions that occur during the process of achieving group decisions until the point when the group decision is made.” Risk is a measure of the probability and consequence of not achieving defined requirements of the project or needs of the stakeholders (Kerzner 2013). A risk contains the following two primary components for a given interaction or event as illustrated in Figure 8.

- Likelihood—probability of occurrence of a consequence, and
- Consequence—either the number of occurrences of the undesirable events/objects or the amount at stake.

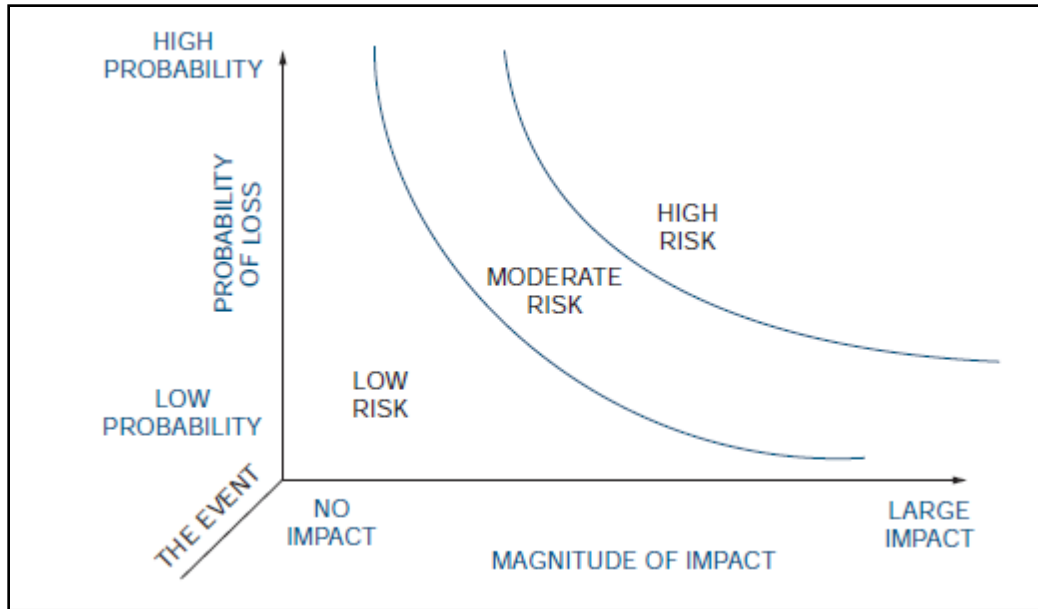


Figure 8. Overall risk is a function of its components (from Kerzner 2013).

As illustrated, simple risk can be conceptualized as a function of the likelihood and consequences as shown in Equation (1).

$$\text{Simple Risk} = \text{Likelihood} \times \text{Consequence} \quad (1)$$

As illustrated in Figure 8, risk increases as either the likelihood or consequences increases.

From Figure 9 (as presented in the NPS lecture on the Life cycle Management Praxis, by Prof. Langford, 2014), it is shown that the relationship between risk and knowledge gained from each event emerging from respective decisions can be deduced analogically from Figure 8. As the level of knowledge of participants in the decision-making group increases, the risk emerging from their decision decreases. The initial decision made is often of higher risk than the subsequent decisions made. With that, the decision-making process is iterated to reduce the level of risk that arises from the emerged event.

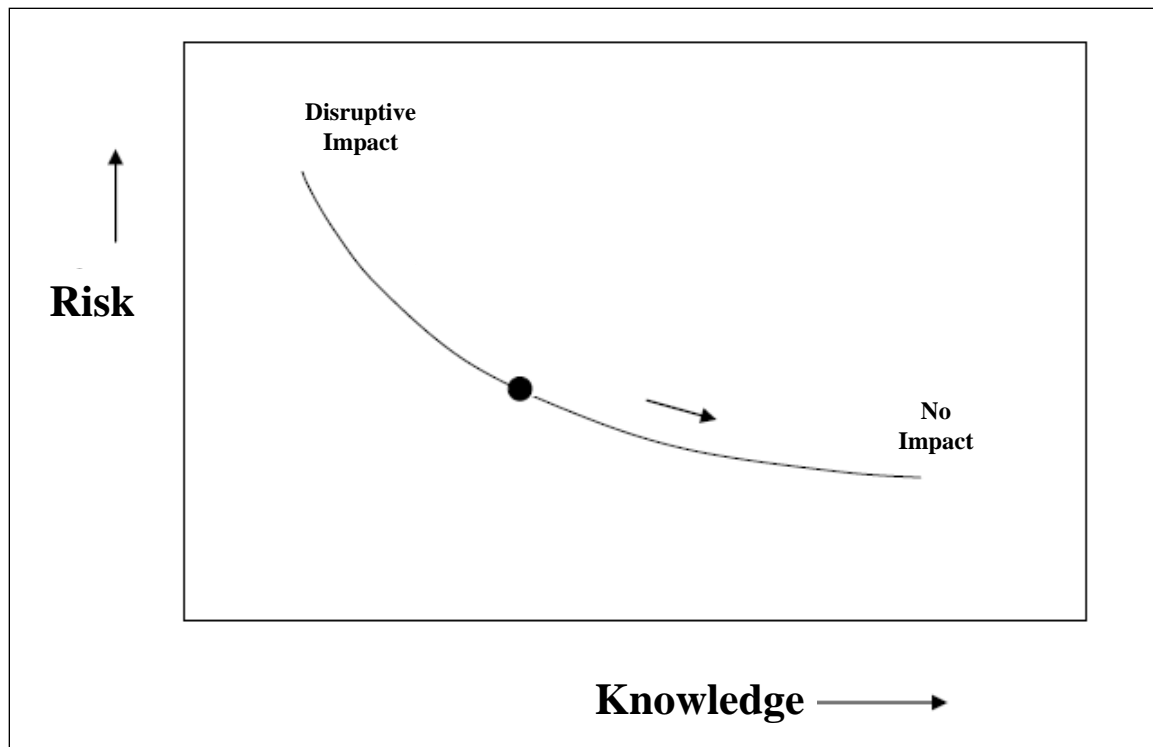


Figure 9. Visual framework to evaluate risk and knowledge (from lecture on Life cycle Management Praxis, Langford 2014).

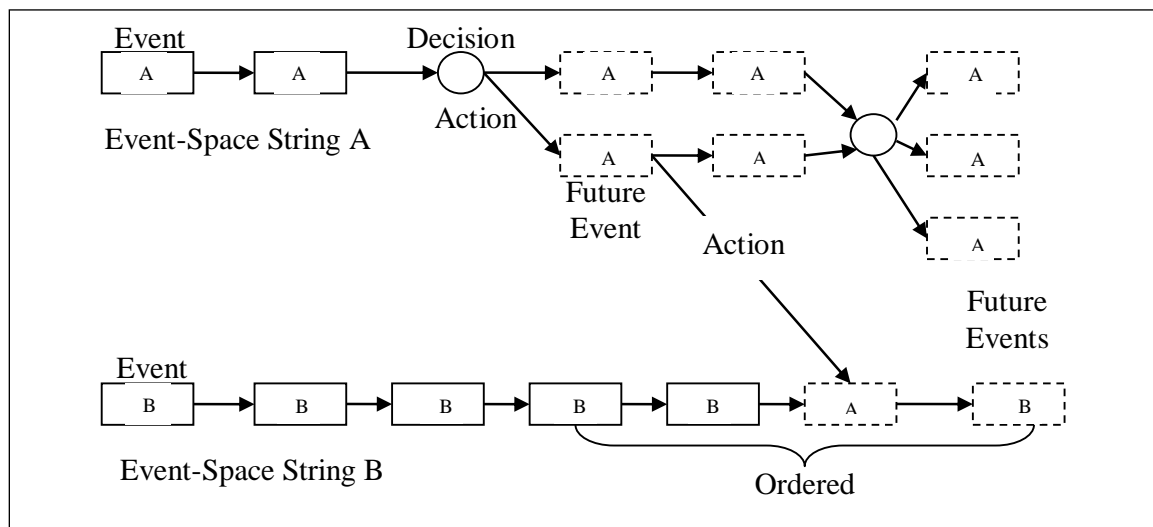


Figure 10. Event-Space Strings (from Langford, Horng, and Lim 2007).

Events are defined to be both logic of actions and causality emerging from decision made. A study was done by Langford and Lim (2007) on Event-Space Modeling

as an analytical method of identifying potentially adverse technologies early and then assessing and evaluating the accompanying risks to established business. Figure 10 shows the Event-Space String Model (Langford and Lim 2007). Langford and Lim (2007) explained that an ordered string of events are those events in a contiguous string of events that satisfy two conditions: two events change in expected value due to existence of the other event; and two events must have causal relationship through context.

In particular, the description of the Event-Space String Model is extracted and quoted as follows (Langford & Lim 2007).

Events specify the direction and magnitude of a development activity in a logical, verifiable fashion, but not the absolute scaling in time, i.e., the rate of development. Even with ‘perfect’ knowledge, there can be intense debate about when certain events occur; therefore time-stamping is problematic. Designations on a time scale are subject to interpretation, whereas the corporal description of an Event using functions, performance, and quality metrics is an absolute. We define an Event as something that happens, irrespective of time. An Event-Space String is a set of instantaneous events that only vary in specificity. Events can be situations, consequences, effects, results, responses, or processes. Event-Space Strings define cohabitation of events through a finite set of binary relations. It is the duty of an analyst to determine the relevance of each Event. Relevance can be represented as probability density functions.

We ascribe one event happening before another by our observation of events. It is the ordering of events relative to a step-wise continuous unit progression that provides the notion of absolute time. Everything is related to previous things, albeit in a manner that may be difficult to discern without sufficient information.

Thus, the Event-Space Model states that an event that occurred is related to the previous decision that is made. Next, Langford and Lim (2007) explain the concept of likelihood supported by the Event-Space Model as per the following quote.

The likelihood that the sum of all potentially disruptive ideas will impinge on the observer’s business in a fashion as given by Equation (2)

$$\sum_{All-Idea/Events} P_e = \sum_{All-Idea/Events} \alpha \delta \quad (2)$$

We assume that there is ordering of events such that the occurrences of future events are dependent on the existence of causal events under

specific conditions. There exists $2^{n(n-1)/2}$ possible belief-network structures with the events ordering constraint. Building the database D consisting of the cases related to the business industry (represented by the directed acyclic structure B_s where the nodes correspond to domain variables $x_1, x_2 \dots x_n$ and the arcs between nodes represent direct dependencies between the variables. Likewise the absence of an arc between two nodes x_1 and x_2 represents that x_2 is independent of x_1 , given its parents in B_s) and the augmented conditional probabilities, we construct the most probable belief-network structure – to maximize $P(B_s, D)$. One such method is the K2 algorithm (Cooper and Herskovits, 1992), and following their notation, to iteratively construct the set of parent events, π_i , for every x_i in Z. Legitimate events are only considered that satisfy the ordering constraint and maximizing the following function as shown in Equation (3)

$$g(i, \pi_i) = \prod_{j=1}^{q_i} \frac{(r_i - 1)!}{(N_{ij} + r_i - 1)!} \prod_{k=1}^{r_i} N_{ijk} ! \quad (3)$$

From a temporal perspective, a group decision is to be made iteratively such that there is a step-wise decrease in the level of risk and increase in the level of knowledge. In addition, each decision should take the previous decision as part of its consideration during framing of the new decision situation. In addition, it is recommended that decisions be made early to allow iteration of the decision-making process to aid in the mitigation of risk of the legitimate events that emerge from the decisions made.

3. Time and Cost Constraints

With the current pace of the business world, the time allowed for decision making is often very short, and the people involved in the decision making are limited according to their budget. The main cost contributor during decision making is the time invested in the human resources. Prior to making a group decision, the collection of data to generate useful information must be resourced accurately. Often, the phase of data collection and information generation for subsequent analysis is the most time-consuming part of the process. An efficient transmission of information and recursive interaction between the elements of the decision-making group and the decision maker(s) becomes crucial.

B. SYSTEMS ENGINEERING APPROACH

INCOSE states that systems engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation. Most importantly, systems engineering considers both the business and the technical needs of all customers with the goal of providing a high quality product that meets the user need (INCOSE 2010).

This study undertakes a systems engineering approach that provides a systematic means of determining needs of people or organizations that have a stake in the outcome of the work. From the identified stakeholders, the needs boundaries are determined to facilitate a closed-end discussion about possible problems that result from not satisfying the needs of the stakeholders. With the recognition of the boundaries drawn around an organization, key stakeholders, and decision-making group, the interaction between them can be examined to determine the framework to achieve a good group decision fit. This approach further allows the identification of external elements that may influence the interaction within and between an organization, stakeholders, and decision-making groups.

IV. ANALYSIS

This section will explore and determine the appropriate principles, theories, models, and approaches used to develop the method and framework that can be used as a guide to making a group decision with good decision fitness under time and cost constraints.

A. PRINCIPLES

Principles are general and fundamental statements that are comprehensive in their applicability to and in consensus with the society or world view (Langford 2012). The following principles are being presented to ensure consistency in the organization of thoughts to articulate derived framework and subsequent analysis:

(1) Principle 1: Decision Fitness

Decision fitness (Strategic Decisions Group 1983) is illustrated as a chain of steps that describe the appropriate frame for the decision, the creative and practicable alternatives that are possible, the meaningfulness and reliability of the information used, the clear values and tradeoffs, the logically correct reasoning, and the commitment to action (Howard 1983). It is important that good decision fitness is achieved under the context of appropriate validity and applicability (scope).

(2) Principle 2: The Principle of Alignment

The alignment of strategies involves the business enterprise, the key stakeholders, and the project to result in better outcomes for product or service development (Langford 2012).

(3) Principle 3: The Principle of Partition

The partitioning of objects can create tractable problems to solve if and only if boundary contiguity is achieved. The partition in an organization should not matter as long as the goal is achieved (Langford 2012).

(4) Principle 4: The Principle of Planning

Integration planning is predicated on pattern scheduling (lowest impact on budget), network scheduling (determinable impact on budget), and ad-hoc scheduling (undetermined impact on budget) (Langford 2012).

B. THEORIES

Gary O. Langford (2012, 371) has explained that “the role of theory is to organize, explain, and predict actions and events.” In addition, theory is predictive and provides guidance based on causality. The relevant decision theories are as follows:

(1) Theory 1: Marginal Theories

From the perspective of economics, the marginal theories are of relevance in justifying ways to maximize profit (Banerjee 2012). The marginal theories are based on the law of diminishing returns whereby there is increment output for every increment input to a business in an organization. The output may be positive or negative.

(2) Theory 2: Mathematical Decision Making

Mathematical techniques (Banerjee 2012), supplemented by the use of computers, have provided considerable aid in decision making. Mathematical models using mathematical techniques is one of the approaches to decision making (Ragsdale 2012). A mathematical model uses mathematical relationships to describe and represent a decision situation. One application of the mathematical model is mathematical programming (MP). With limited resources in an organization, MP, also known as optimization, is a field of management used to find the optimal and efficient use of available resources during decision making. Operations research (OR) can be used to practically eliminate the need for judgment in deciding specific questions that contain precursory knowledge or know-how. Finally, a validated mathematical model allows a comprehensive consideration of all the essential input factors in a decision situation.

(3) Theory 3: Psychological Theories

Theory 1 (marginal theories) and Theory 2 (mathematical model) presume that the decision maker is an economics-oriented person, that is, a profit seeker. On the other

hand, Herbert A. Simon counters that, from psychological perspective, an organization attempts to achieve satisfaction in priority to maximizing profit (Banerjee 2012). It is implied that one begins the real search for more profitable or rewarding courses of action when the level of attainment falls short of the initial expected satisfying or adequate level.

Research was conducted to investigate the reciprocal relationship between mental modes of conflict and various forms of dysfunctional social relations in organizations (Halevy, Cohen, Chou, Katz, and Panter 2013). The concerned elements include, experience of task and relationship conflicts, interpersonal hostility, workplace ostracism, and abusive supervision. Intuitively, it can be recognized that conflict causes biasness in group decision making.

The results of research showed that there are positive and moderate correlations between conflict at work and anxiety and frustration, between conflict at work and physical complaints, and between conflict at work and the exhaustion dimension of burnout. Therefore, it is important to ensure that members of a group are motivated to reduce conflict at work and find constructive ways to manage and resolve disputes. The elimination of conflicts causes the emergence of harmonious interaction at workplace that aid in a group decision-making.

(4) Theory 4: Rational Choice

As described by Banerjee (2012), characteristics of rational decision making include:

- Decision making will follow a systematic approach from the decision situation to the solution. Rational decisions seek to optimize or maximize utility,
- The chosen solution will be in agreement with the preferences and beliefs of the decision maker,
- The rational choice will satisfy conditions of logical consistency and deductive completeness,
- The process of group decision making will be objective, unbiased, and factual. It is further supported by the generation of information that is used for subsequent analysis,

- Future consequences are being considered for each proposed alternatives,
- A structured framework is used to encourage a broad and deep analysis of the decision situation, and
- Risks are analyzed using a mathematical approach.

While the rational decision-making process seems to be the ideal, there are three main areas of limitation with choosing rationality. First, there is a limit on human ability to gather, process, and appreciate all the information necessary to optimize a decision outcome. Second, there is limit on the availability and accessibility to information and knowledge. The model assumes that one can gather sufficiently comprehensive information in terms of quantity, quality, accuracy, and integrity. It further assumes that one possesses knowledge of the cause and effect relationships that is crucial for the evaluation of alternative situations. Third, there is a limit in time. The search for optimum solutions will generate a delay that could cause a negative impact to the potential benefits of the chosen alternatives. It is essence driving force that decisions be made promptly and swiftly in preparation for subsequent corrective action.

While there are limitations to executing a rational decision-making process, it is important to recognize the benefits of having a rational choice. The benefits derived from rational choices include the following (Banerjee 2012):

- Complex decisions can be systematically addressed by breaking them down.
- The framing of the decision situation ensures that the needs and requirements of stakeholders are fulfilled.
- The process is guided by structured techniques, mathematics, and computers.

While there are limitations in a fully rational decision-making model, the ideal serves as an invaluable aid to decision making. When faced with complexity and big data, emphasis can be placed on enhancing capabilities that support rational choices.

(5) Theory 5: Theory of Needs

There is a fundamental assumption that human culture has a basic instrumental character that provides the means for satisfying individual and social needs (Sztompka 1974). Classification schemes were developed by Malinowski to link particular needs

with respective cultural reactions. The first group of needs includes the basic needs that have a biological character made up of the anatomical and physiological constitution of the human being. Regardless of where one lives or practices certain types of civilization, basic needs include the following (Sztompka 1974):

- All men have to eat.
- All men have to breathe.
- All men have to procreate.
- All men have to eliminate waste matter from their organisms.

The basic needs are satisfied by men in different ways as it is influenced by their respective concrete social and cultural circumstances. In the process of satisfying the basic needs, newly derived needs are generated. The derived needs are equally as significant as the basic needs. The catalogue of basic needs and derived needs, linked with specific cultural reactions, are shown in Table 1 and Table 2.

Table 1. List of basic needs with respective specific cultural reactions (from Sztompka 1974).

Cultural Reactions (elements E of the system)	Basic Needs
1. Nutritive system	1. Food, nutrition
2. Kinship structures, family, schools	2. Reproduction, procreation, upbringing of children
3. Shelter, houses	3. Bodily comfort, necessary temperature, climatic conditions
4. Weapons, fortifications, army organizations	4. Safety
5. Various activities, sports	5. Movement
6. Hygiene, therapy	6. Health

Table 2. List of derived needs with respective specific cultural reactions
(from Sztompka 1974).

Cultural Reactions (elements E of the system)	Derived Needs
1. Economic system	1. Production, utilization, and reproduction of the material apparatus
2. Political organization	2. Organization of collective activities, necessity of authority, leadership, power and sanctioning apparatus
3. Social control	3. Codification and regulation of human behavior by means of sanctions
4. Educational system	4. Transmission of acquired cultural heritage

C. MODELS

A model is a relation or set of relations between variables that are representative of an object or process (Langford 2012).

(1) Model 1: The Bounded Rationality Model

The Bounded Rationality model is used for the generation of the proposed framework for making group decisions (Banerjee 2012). The Bounded Rationality model addresses the difficulties encountered during the realization of a complete and rational model. The Bounded Rationality model acknowledges the human cognitive and environmental limits and suggests that one act rationally within these constraints. Many decision-making theories are reverse engineered and construed after scrutinizing the consequences of bounded rationality.

(2) Model 2: Mental Model for Decision Making

From the third lecture of SI4021 Systems Engineering for Product Development taught at NPS (Langford 2014), Figure 11 shows the typical mental process when one is involved in a decision-making process. It involves both the intuitive and analytical skills.

To decrease the time taken to make a group decision, the time spent from (7) Intense Ideation to (11) Incubation can be decreased. A lesser amount of time is allocated to do generation of alternatives or different opinions. However, the time reduction

involves taking a higher level of risk and affects decision quality. For instance, it might result in more money being invested subsequently to do rework and retrofit. This approach can be coupled with the Principle of Alignment such that, if there is misalignment in terms of goals or objectives, decisions should be made early to allow rectification and cost savings.

To increase the decision quality, the time spent on (7) Intense Ideation, (8) Idea Generation, Hybridization and Evaluation, and (11) Incubation shall be increased. Time is well spent on generating and analyzing a comprehensive set of alternatives or different opinions such that the solution space is adequately explored. The time invested to do generation and evaluation of the alternatives will result in a positive impact on decision quality.

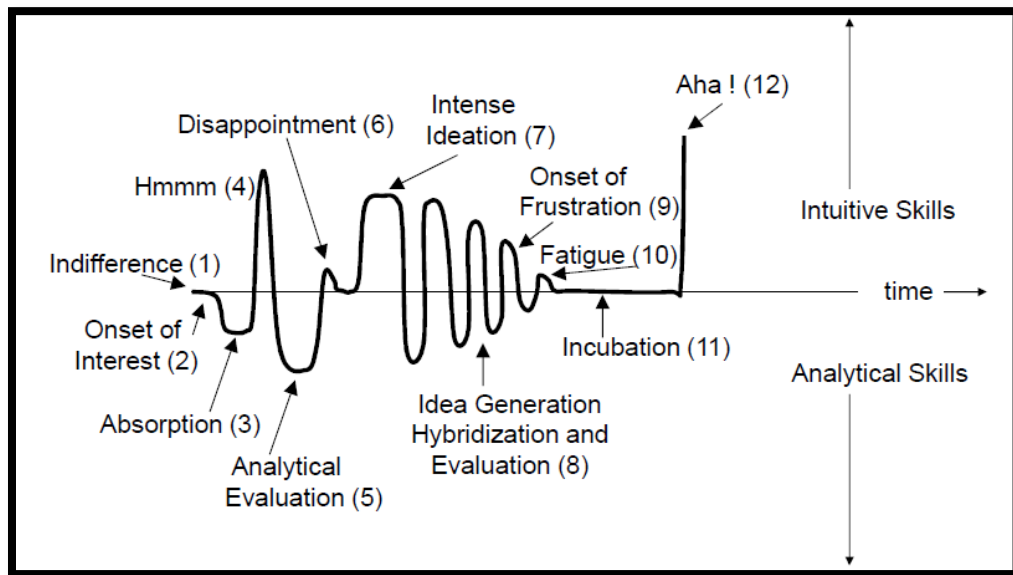


Figure 11. Typical mental process for decision making (from Langford 2014).

D. APPROACHES

The following potential approaches to group decision making are proposed to ensure good decision quality under time and budget constraint:

1. Select one category of decision theory for decision making.

2. Select several categories of decision theory, sequence and adapt them in accordance to the different phase of decision making.
3. Select several categories of decision theory and contrast them for decision making.

E. METHOD

The definition of method is as follows (Langford 2012, 363):

A method is an overall plan or a set of specifications for accomplishing objectives, from the perspective of the person designing or carrying out the method.

In an organization, members of a group are often pre-determined. Therefore, it is assumed that a group of people has been appointed to do decision making. As taught in DQ101 Introduction to Decision Quality taught by Carl Spetzler, Ph.D. (Strategic Decisions Group 2014), the critical steps to decision making for any chosen approach are as follows:

(1) Appropriate Frame

The group doing the decision making shall have a clear purpose and well-defined scope. In addition, there shall be a common understanding on the controllable variables and uncontrollable variables. Uncontrolled variables are usually environmentally related. Finally, the potential constraints and limitation must be listed. Constraints may include time and budget allocated to the situation. Limitations may include availability of relevant technology and accessibility to certain classified information.

(2) Information

Data shall be collected and analyzed to generate a comprehensive set of information through a decision tree, an influence diagram, a tornado chart, assessment techniques, and statistical analysis. The information must be meaningful and reliable such that it represents the current and forecast the future. As mentioned previously, the generated set of information is crucial in providing a holistic view of current and future to the group of people involved in decision making. It aids in providing an expansive frame to decision making to ensure a comprehensive coverage of potential alternatives. On the other hand, it enhances the reductive frame through the reduction of uncertainty and

systematic revision of information in light of new learning. This holistic view will aid in the elimination of any of the six categories of bias.

(3) Alternatives

A comprehensive set of significantly different alternative decisions must be generated by the team through use of creative methods, systematic research, and strategy tables. It is important that the alternatives do not result in similar performances. This restriction is to ensure that the solution space is being explored adequately. It is desirable to generate as many alternatives as possible so that there is a higher probability of achieving a decision that is of high decision quality and meets the objectives of stakeholders.

(4) Analysis of Alternatives (AoA)

A set of decision criteria that fulfills the objectives of the stakeholders shall be identified by the group. The decision criteria, coupled with logical and correct reasoning, are used to evaluate the set of alternatives to determine the most valued decision. The evaluation may be qualitative or quantitative or both. Qualitative study involves the examination of the advantages and disadvantages of the alternatives. Quantitative studies may involve a ranking system based on decision criteria or weighting system. Some examples of evaluation methods may include Pugh's Matrix, comparison of Utility Value Curves, Cost-benefit Analysis, and Sensitivity Analysis.

(5) Tradeoff Analysis

There is a limit to how comprehensive a set of information can be acquired and then developed by a group. Therefore, analysis is often made with insufficient information. After the decision matrix from the Analysis of Alternatives (AoA) has been generated, further tradeoff analysis can be done. Tradeoff analyses are done to assess potential impact to constraints that include time and budget.

(6) Determine Decision Approach and Final Decision

Finally, decisions shall be made by the group based on the determined decision approach.

(7) Execution of Decision

The decision is then incorporated into a plan for immediate execution together with identified schedules and budgets.

In the event that the decision-making group is not formed, two additional steps shall precede the previously identified steps (1) to (7) as follows:

1. Understand the Magnitude of the Decision

The initiator shall have a brief understanding of the current situation that requires a decision to be made.

2. Form Groups

The awareness of the nature and severity of the decision allows the initiator to determine the size of the group and its functional constituents. At the same time, consideration shall be given to the difference in cultures and communication styles across the different strategic business units.

The previously discussed steps are summarized in the flowcharts in Figure 12, Figure 13, and Figure 14.

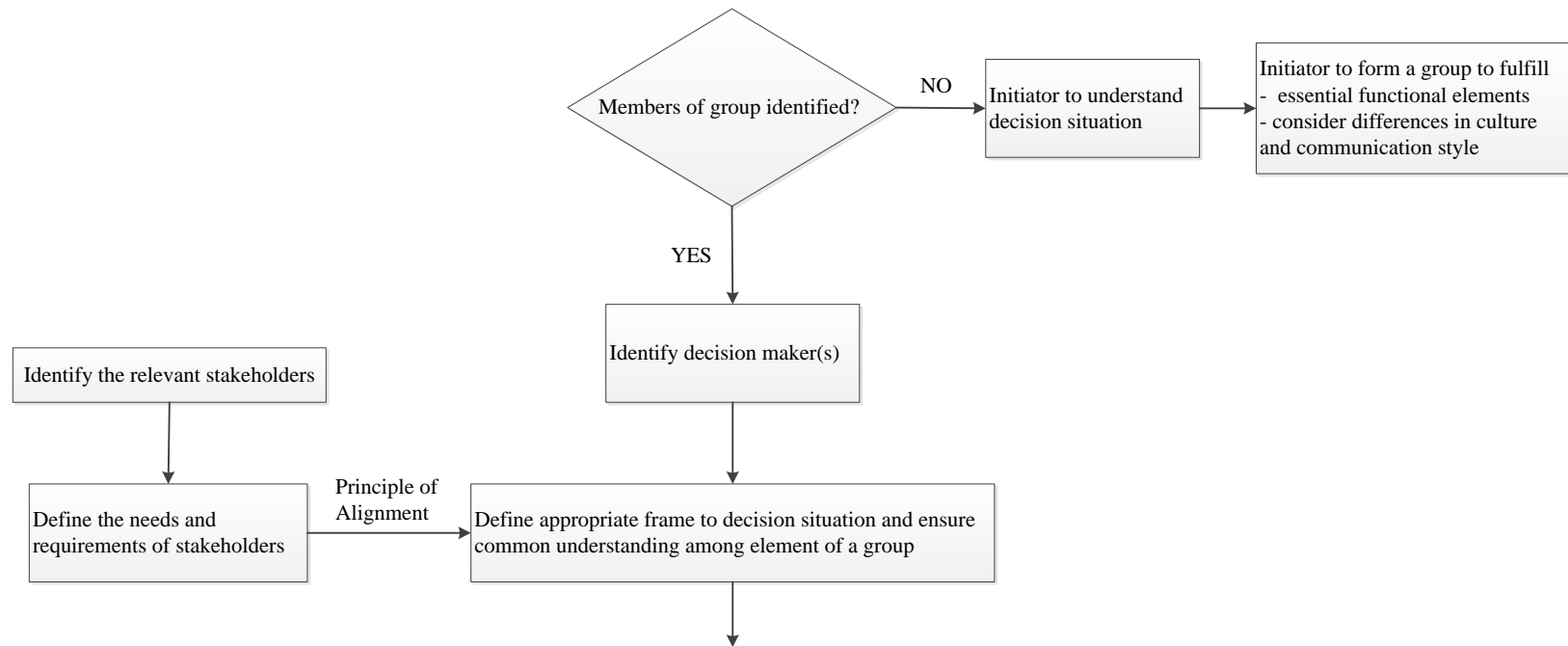


Figure 12. Flowchart for group decision-making—Part 1 of 3.

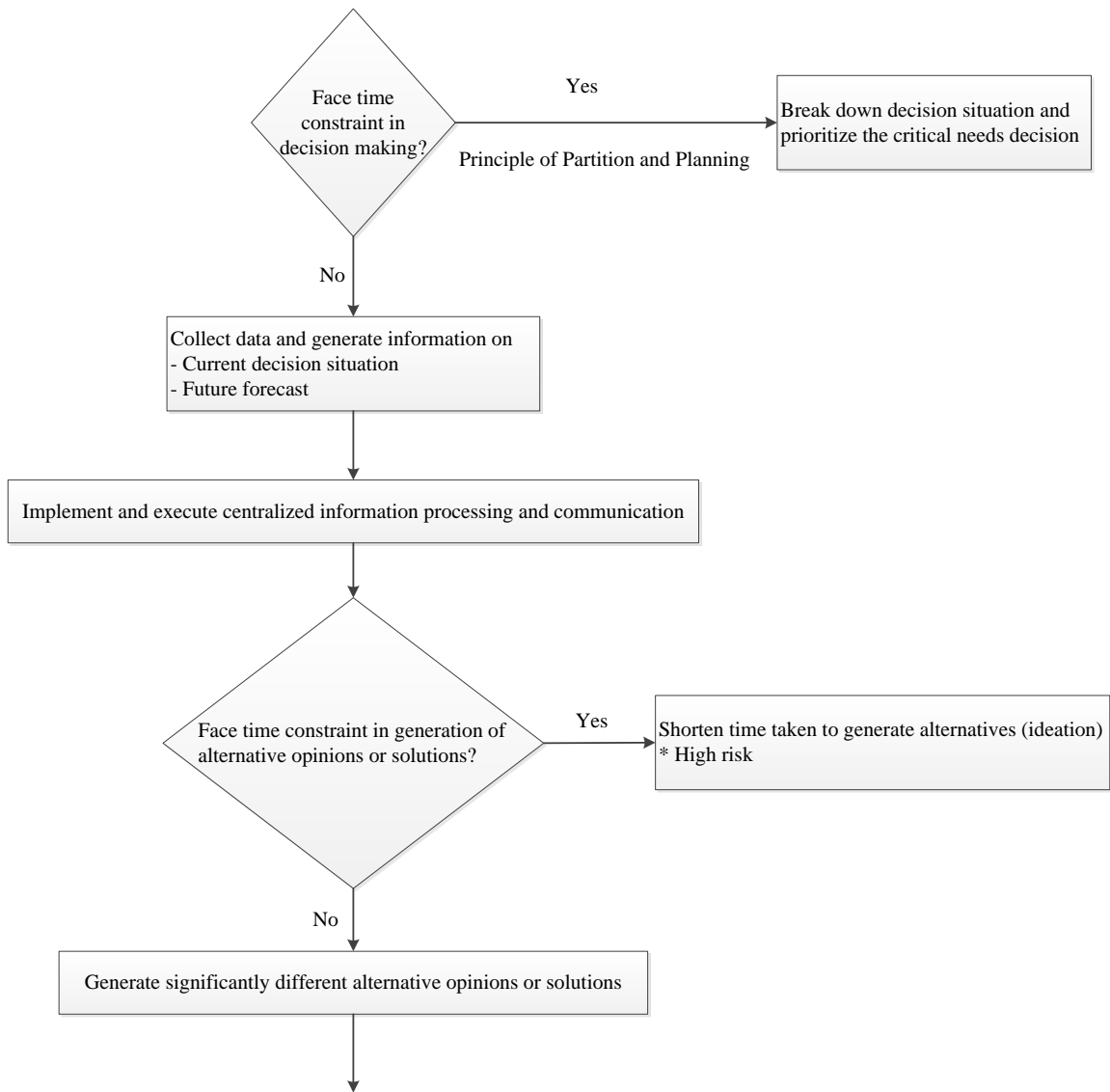


Figure 13. Flowchart for group decision making—Part 2 of 3.

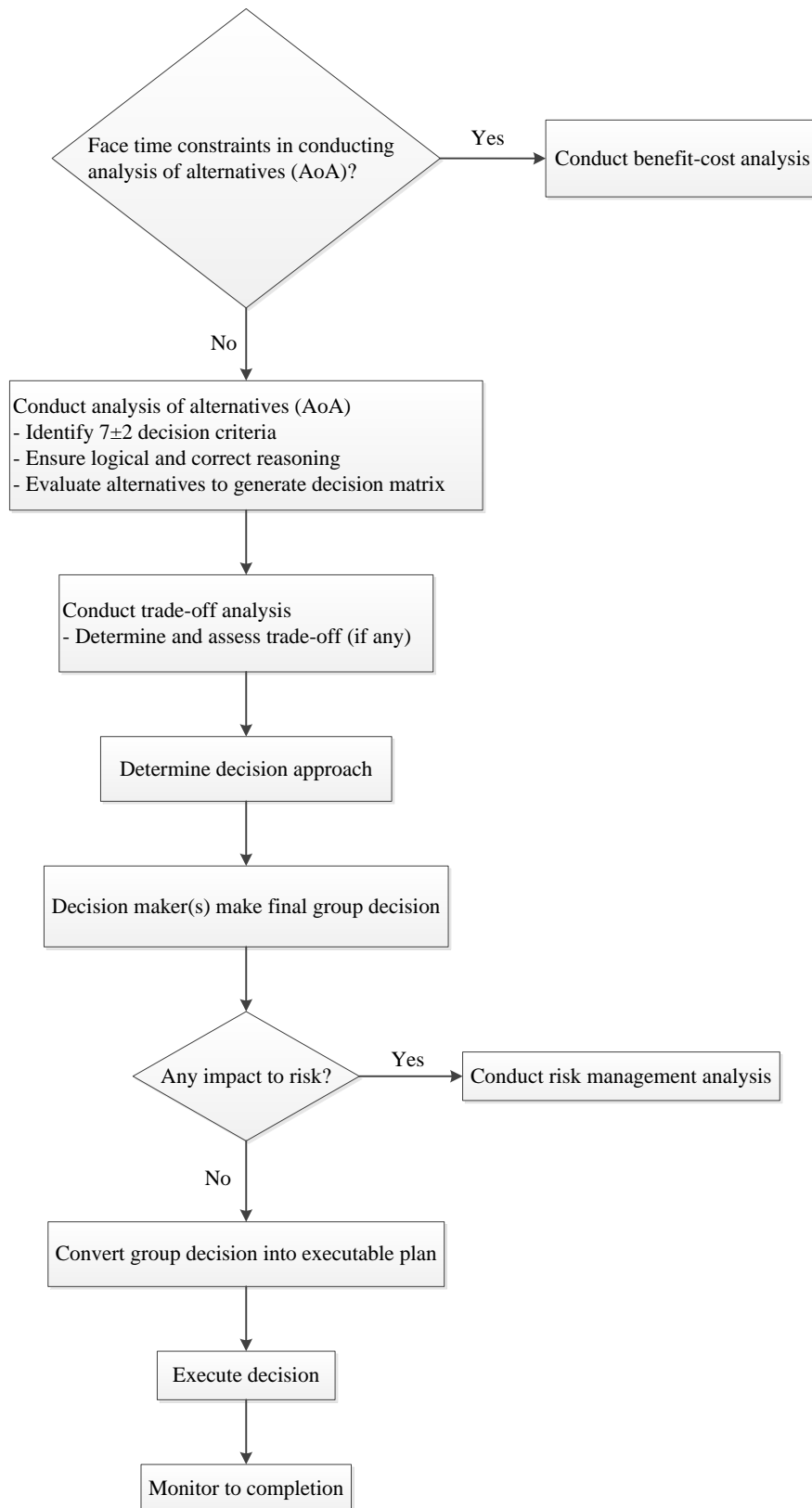


Figure 14. Flowchart for group decision making—Part 3 of 3.

F. FRAMEWORK

A framework is the logic and consistency of methods for a group of frames (Langford 2012). The approach taken to develop a consistent and utilitarian framework for making group decisions applies the previously discussed principles to explain the empirical phenomena that predict new behaviors that should be observable in all systems (Langford 2012). The proposed framework embraces the assumptions discussed in the following sections.

1. Assumption 1: Assumption of Self-Regulation

Assumption of self-regulation (Sztompka 1974) describes the behavior of a system from an internal point-of-view (i.e., translucent-box approach). The focus is on the “molecular” characteristics of system elements and their interrelations, and especially the ways in which they can account for the directive mode of system’s “molar” transformation.” While facing a changing external environment, the “molar” assumes that one is continuously looking for a built-in mechanism that steers and motivates the system towards its goal or continues to preserve the goal state once it has been attained. According to Sztompka (1974), the following three conditions are necessary to trigger the self-regulating mechanism.

1. The initial state must belong to the class of preferred states, or it must be a necessary phase in the causal chain of development leading to the preferred state (the self-regulating mechanism is always relative to a given selected class of states, the system that would be self-regulating with respect to all conceivable states is impossible by definition).
2. The initial change must be strong enough to throw the system out of preferred state.
3. The initial change must not overrun the limits of compensatory abilities of the given systems.

A self-regulating system is characterized by its structural properties.

2. Assumption 2: Assumption of Integration

The assumption of integration of systemic goals claims that there is a wide class of individual purposes, the attainment of which is the condition (either sufficient, necessary, or favorable) of the attainment or maintenance of the preferred global or partial states of the system as a whole (Sztompka 1974). According to Sztompka, while human beings strive to realize their own purpose, this act leads to the attainment or maintenance of the preferred states of society as a whole. This enactment is called sociocentric purposes, and it is equivalent to the subsequent referred to as the basic value or goal orientation of the society. It is deduced that the goals of the members of a group must hold these values sufficiently in common to motivate the performance of the functional requisites of the group.

3. Assumption 3: Assumption of Manifest and Latent Functions

The assumption of manifest functions claims that the acting individual is usually aware of the immediate or remote consequences of his actions for the system as a whole (Sztompka 1974). On the other hand, the assumption of latent functions claims that the acting individually rarely (either intentionally or unintentionally) recognize the consequences of the activity for the system (Sztompka 1974). The perception of the actor of the world is so limited in numerous ways that he becomes ignorant of the potential consequences of his behavior. A system is considered here as a group of people interacting to allow transfer of energy, matter, material wealth, and information (EMMI) that will lead to the completion of decision making.

As discussed earlier, there are three different types of decisions, strategic, significant, and quick. To overcome the organization (or group) complexity and analytical complexity, the proposed group decision-making framework in a hierarchical organization is illustrated in Figure 15. The red arrows represent the interaction between the decision maker and the key functional representatives in a decision-making group. The blue arrows represent the interaction between the key functional representatives and the lower level supporting members from the respective functional departments. The black arrows represent the interaction between the supporting member and respective

members from the lower chain of the same functional departments in an organization. Regardless of colors, the double-headed arrows represent an interaction that is a recursive connection and have recursive cohesion. In addition, with the assumption of self-regulation, there is an element of trust and respect during the interaction. Finally, the purple arrows show that there is a presence of 100 percent consensus in a group decision occurring at all levels in an organization. The principle of decision fitness and differences of opinion have been described as the basis of building the proposed group decision-making framework.

DM represents the group decision maker(s). F1, F2, F3, and F4 represent the key functional members that belong to the group doing the decision making. Each functional member may be supported by respective sub-groups. The main role of the sub-groups is to do generation of information and execution of plans. The group decision will be made based on 100 percent consensus. The hegemony of a unanimity rules in a group decision-making process provides the motivation to allow equal status among members, and fosters balanced participation during decision making and avoids making bias decisions.

According to SE4151 Systems Integration and Development, Lecture 2 (Langford 2014), interactions will occur only when there is a transfer of EMMI between two or more people. The first set of interactions occurs between the decision maker(s) and the key functional members. The second set of interactions occurs between the key functional members and respective sub-groups. Depending on the decision situation, the two sets of interaction can take place sequentially, concurrently, iteratively, and/or recursively during the entire course of group decision making. Furthermore, the interaction is done with the assumption of self-regulation. These are the essential elements of trust and respect during the process of interaction between the element of a group or organizations (Sztompka 1974).

The proposed framework involves a recursive connection between the two sets of interacting parties. According to SE4151 Systems Integration and Development, Lecture 4 (Langford 2014), there is a strong structural cohesion resulting from a recursive connection and a weak coupling between the interacting parties, as illustrated in Figure 16. Connection is the physical pathway between elements of a group or organization.

Coupling is the degree of dependency of one element on another within a group or organization. Coupled elements within a group or organization will allow the transfer of EMMI. It is desirable to have weak coupling between two elements, as it results in low dependency of one element on another. Any change in one element does not necessitate a change in the adjacent coupled element. Cohesion is causal and results in the unity of functionality or process for a given input. In addition, cohesion is influenced by the clear definition of the output procedure of an element. There is high cohesion between two elements when the respective functions and processes are strongly related in terms of the inputs and outputs. Therefore, the proposed framework has an inherently strong structural cohesion that is desirable as there is resistance to dissolution under external perturbation. At the same time, there is favorable internal connectivity and capability for coordinated reaction within the coherence elements of a decision-making group and organization.

In a hierarchical organization, a centralized communication network facilitates a rapid resolution of problems and promotes stability within a group or the organization (Scott 2003). Research by Arrow (1974) shows that having a centralized communication network is important to reduce the high cost involved in the transmission of information. The high cost contributor is the time element invested by individual human resource. With that, it is definitely more efficient and less expensive to transmit all pieces of information to a central area than to disseminate information piece by piece to everyone. Therefore, based on the context of proposed framework, the information shall be communicated via a centralized system. Two examples of a centralized communication network are the chain and wheel network that are shown in Figure 17 and Figure 18, respectively.

With the previously proposed framework, the result is an emerging centralized network. The centralization and consolidation of information is essential to arriving at a quality group decision (Scott 2003). Using the same arguments, Arrow (1974) concluded that centralization of decision making via formation of a focus group can serve to economize on transmission and handling of information. The centralization of decision making facilitates and helps to ensure information security when competition is fierce. Consequentially, a good decision quality will result in benefits such as leadership

emergence, member satisfaction, and social influence (Scott 2003; Gunnarsson 2006). As an organization requires good leaders, the identification of potential leaders will allow investment of appropriate and essential training to groom the talent further.

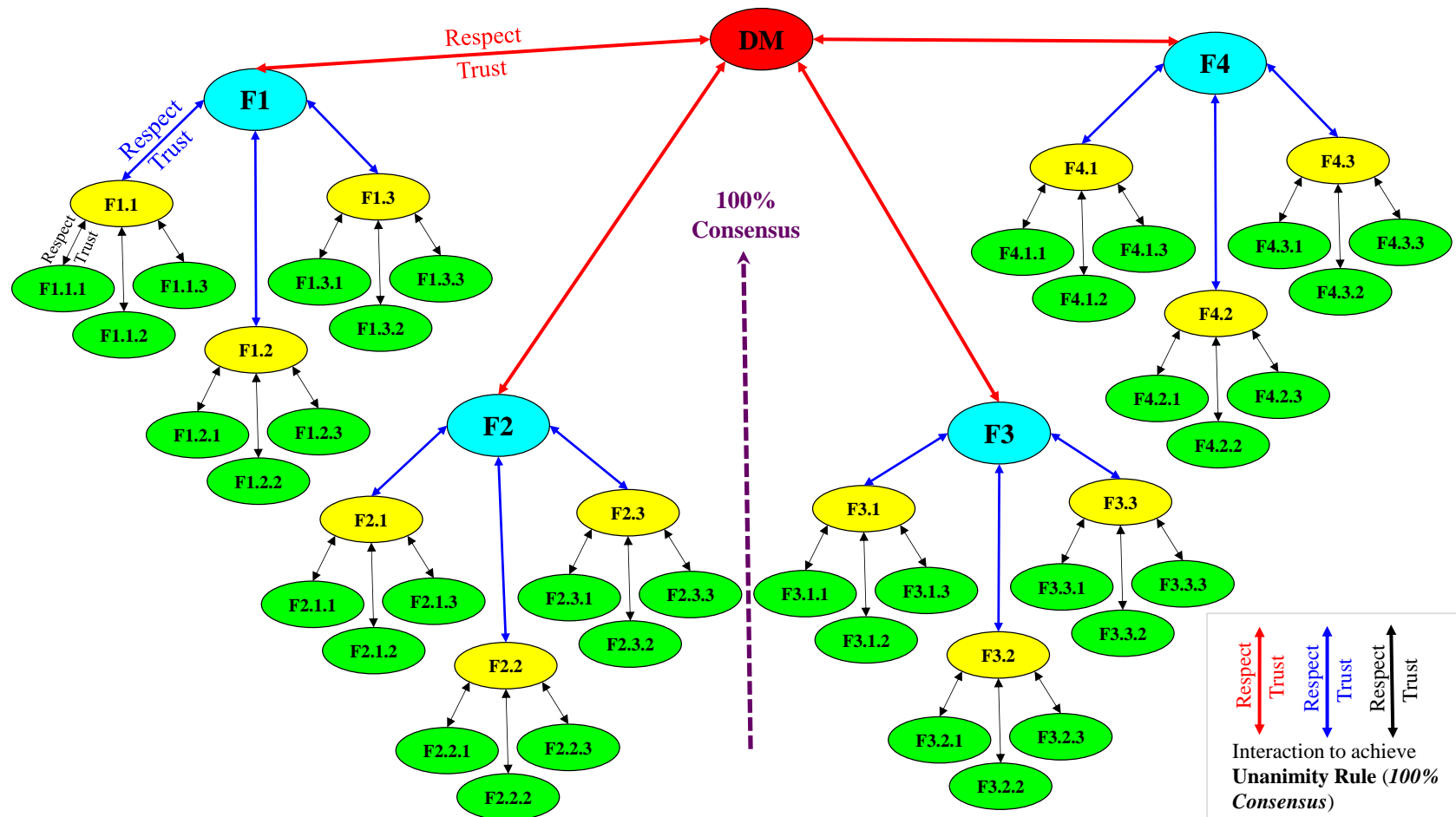


Figure 15. Proposed group decision-making framework.

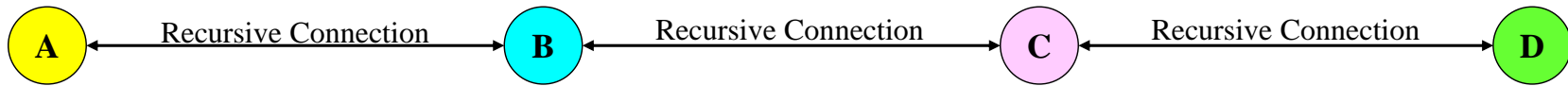


Figure 16. Strong Structural Cohesion = Recursive Connection + Weak Coupling.

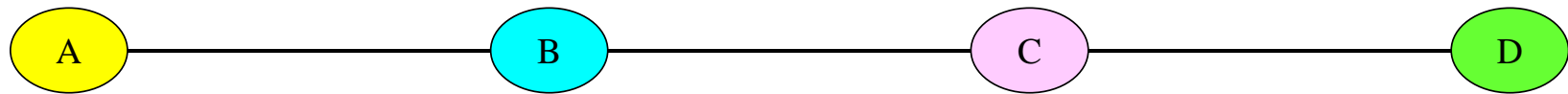


Figure 17. Chain Communication Network.

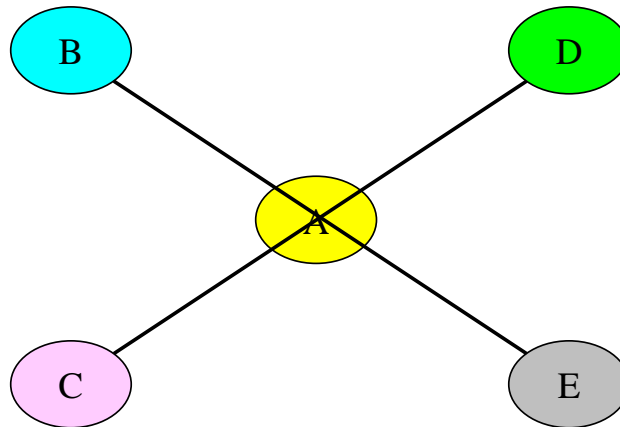


Figure 18. Wheel Communication Network.

G. ANALYSIS

1. Current Group Decision Making Framework in an Organization

Group decision making has become ubiquitous in any organization (Sinclair 1992). Based on a dominant ideology of teamwork, focus groups have often been embraced as a tool that has acquired the status of multi-purpose panaceas for organizational problems that require decisions (Sinclair 1992). The current group decision-making framework in a hierarchical organization is illustrated in Figure 19. DM represents the group decision maker(s). F1, F2, F3, and F4 represent the key functional members that belong to the group responsible for decision making. Each functional member may be supported by the respective sub-groups. The main role of the sub-groups is to generate information and execute plans.

Similar to the proposed group decision-making framework, two sets of interactions must occur in the group decision-making process. According to SE4151 Systems Integration and Development, Lecture 2 (Langford 2014), depending upon the decision situation, these two sets of interactions can take place sequentially, concurrently, iteratively, and recursively during the entire course of group decision making. However, the interaction is potentially comprised by weak structural cohesion that results from weak connection and strong coupling.

Based on current decision situations in an organization, a group can make a decision in many ways. First, one person can make decisions on behalf of the group. This person can be the appointed decision maker of the group or one of higher rank or seniority that is either within or outside the group. Second, decisions can be made by an appointed decision maker (or decision makers) based on a majority opinion or agreement. Third, decisions can be made by appointed decision maker(s) based on 100 percent consensus from all the members belonging to the decision-making group.

2. Bias

As taught by Carl Spetzler, Ph.D., in DQ101 Introduction to Decision Quality (Strategic Decisions Group 2014), there are six biases that affect decisions, including

automatic association, protection of mindset, social influences, habits and personality, faculty reasoning, and relative thinking. Bias has a negative impact on decision quality. In an organization, there are constant influences from outside the decision group that affect elements within a group. Figure 20 displays the undesirable external influences while Figure 21 displays the resulting bias in subsequent feedback, interaction, and decision making within a sub-group and decision group. Negative influences from within a group affects common elements within that group, and may exist in the form of pressure to conform to the majority. Such a phenomenon has similar effects on decision quality. Conformity due to peer pressure generates the phenomenon of groupthink, and can impede the healthy exchange of opinions and information (Sinclair 1992). The emergence of unanimous decisions can be seen as an easily won consensus that will betray a condition of group powerlessness and sacrifice group effectiveness.

While a focus decision group appears to satisfy tasks and fulfill objectives, there is a need to understand the rationale and driving factor behind it (Sinclair 1992). Based on Maslow's hierarchy of needs, there is a desire to satisfy needs for sociability, self-actualization, and participative management. From an organizational perspective, there is a desire to satisfy organizational needs for productivity, organizational development, and effectiveness. In accordance with the social exchange theory by Gouran (1994), a group is not seen as a holistic unit but as a number of interacting individuals (Gunnarsson 2006). Participants of a group are profit seekers; that is, they try to maximize rewards and minimize costs. Rewards are defined as events that individuals find pleasurable, while costs are defined as events that cause individuals to experience pain. According to SE4151 Systems Integration and Development, Lecture 2 (Langford 2014), an event is defined as an activity that relates an input EMMI to an output EMMI through a causal mechanism. According to reinforcement theories, the more rewarding an interaction or behavior is, the higher the chance an individual will repeat that interaction or behavior as compared to an interaction that is painful. Thus, there is conflicting influences within a group and therefore a certain degree of bias present in the process of group decision making.

The proposed framework and method of making group decisions is constructed such that miscommunication and bias can be eliminated or minimized. First, the principle of decision fitness forms the basis of the developed chain of steps for making group decisions and will ensure that the context of the decision situation is well defined, recognized, and acknowledged by the group. The scope of the required group decision must be construed accurately at the beginning of the process of decision making. Second, the framework and method embedded within the chain of steps is the identification and evaluation of different opinions. The opinions may include alternative solutions or weighing the pros and cons of the suggested solutions. The generation of alternatives will allow the decision group to adequately explore the solution space and gain insight by simply looking beyond the capabilities of the current proposed solutions.

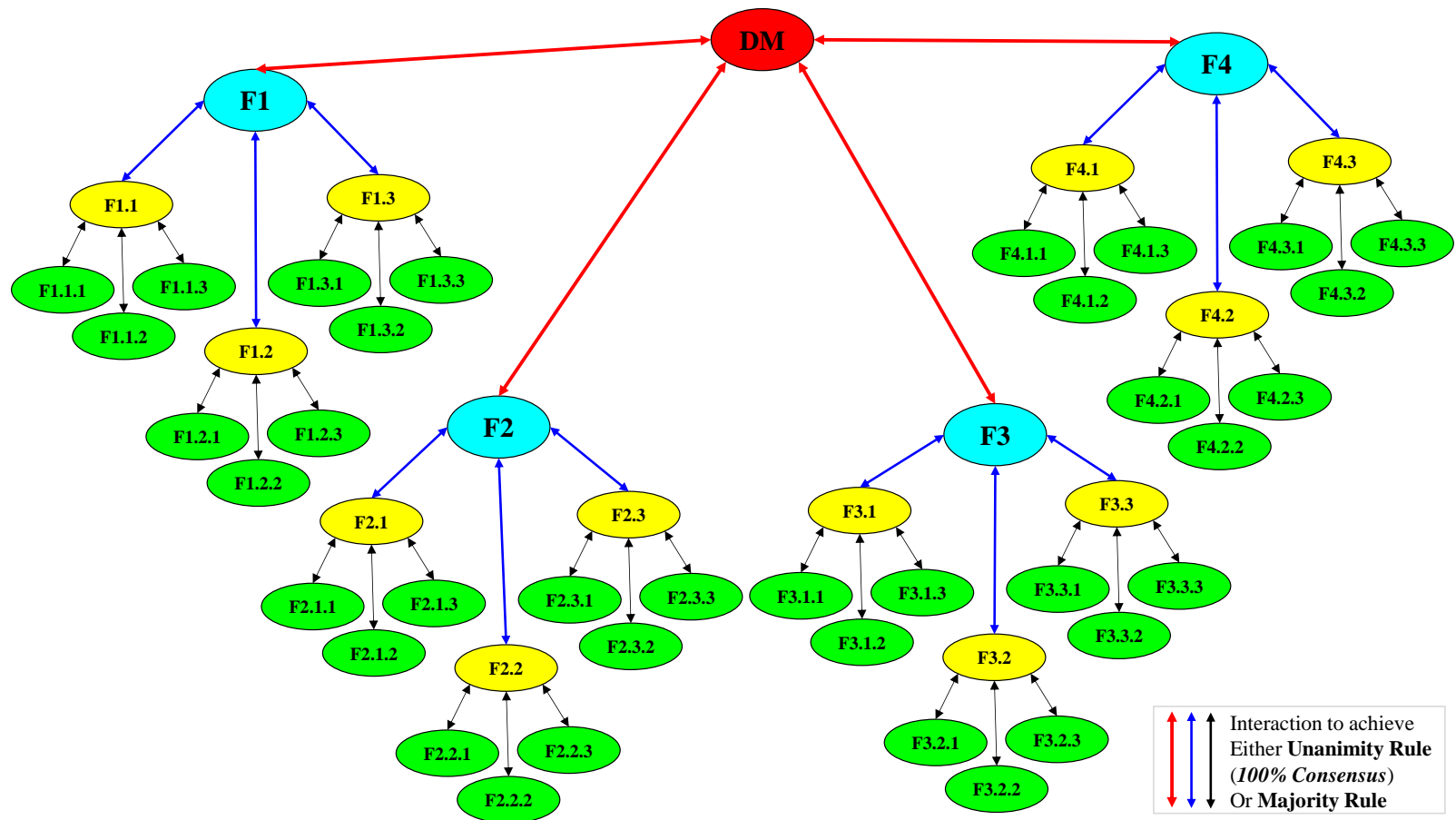


Figure 19. Current framework for making group decisions in an organization.

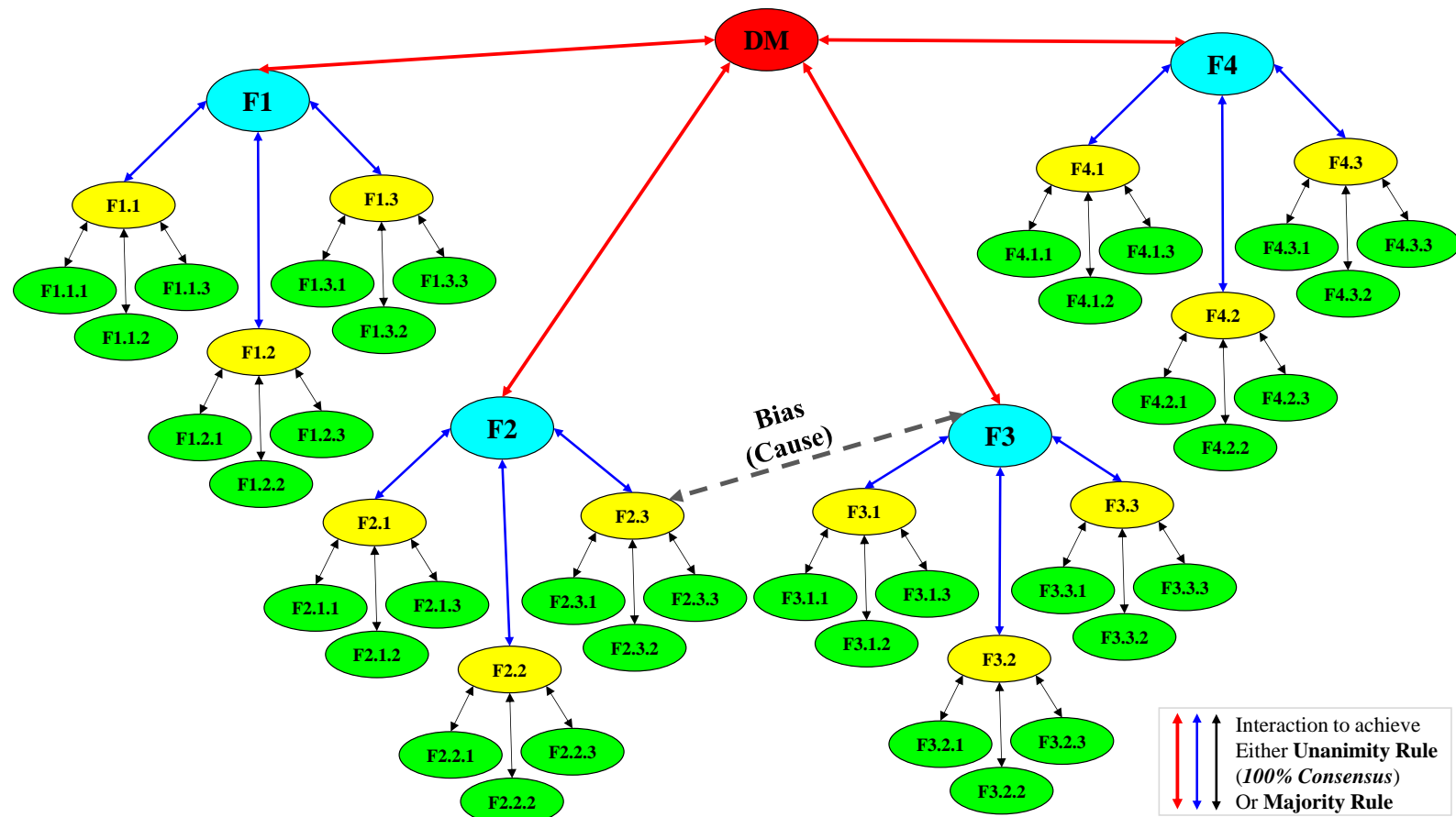


Figure 20. External influences.

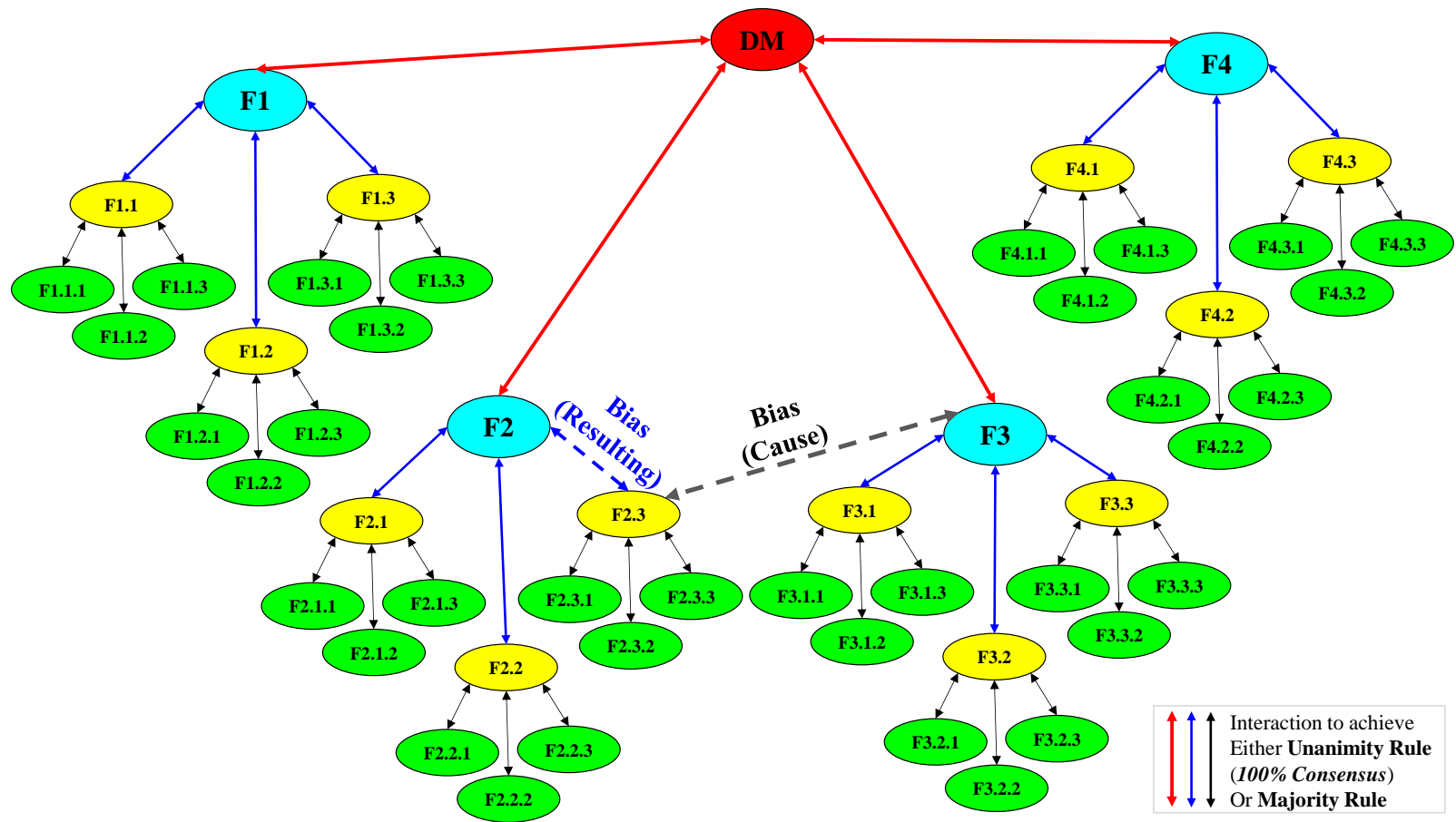


Figure 21. Resulting bias in interaction that affects decision quality.

3. Stakeholders

A stakeholder is anyone who significantly affects or is affected by decision-making activities (Howard 1983). From an organizational perspective, a stakeholder is typically an entity or a person either acting alone or representing an organization. In addition, a stakeholder can influence the conceptualization or funding of a development project, or the acceptance of a product or service, operations, or disposal phase of its life cycle. It is important for a group to acknowledge that stakeholders have needs that translate into specific requirements that are critical to the interest and knowledge of the decision-making group. Stakeholder analysis allows a systematic gathering and analyzing of qualitative information to determine whose interests should be taken into account during group decision making.

The proposed group decision-making framework must further integrate seamlessly with relevant stakeholders and its organization through the principle of alignment. As shown in Figure 22, the decision group must interact with its parent organization through the principle of alignment.

Causality is defined as follows (Langford 2012, 75):

With interaction as the foundation of systems, causality of events is promoted by the concoction of objects, mechanisms, and behaviors that have conspired or occurred. Objective causalities are posited to be both necessary and sufficient to render a complete explanation of an event or a sequence of events.

This is how a cause and effect can be determined.

The framework for objective causality is defined as follows (Langford 2012, 81):

A framework for objective causality applicable to interaction and integration was developed to reconcile the sociological aspects of system integration and subjective factors with the physical and functional aspects of the product and service during development, integration, and operation.

Subjective factors include integration methods, processes, activities, and acts.

Figure 23 displays the developed objective causalities framework, and Figure 24 displays an alternate view of the integrative framework. The framework of objective causalities shows the results of the work efforts managed under natural regime processes.

The elaboration on the objective and subjective framework is as follows (Langford 2012, 84–85):

The objective framework represents the product or service domain that includes the physical objects, the product or service functions, and the objective behaviors that are determined or anticipated from the decision made. The subjective framework is derived from social process that describes the cognition and cognitive structures that deal with objects. The subjective framework represents the social and management domains that include the cognition, procedures, and models.

Langford (2012, 88) explained that “the decision-making group must align with the parent organization in terms of product or service domain (behaviors, functions, and objects), and social and management domain (cognition, procedures, and models),” as illustrated in Figure 22.

Next, there must be concurrent alignment between (1) the parent organization and stakeholders, and (2) the decision-making group and stakeholders. The proposed interaction framework between the parent organization and stakeholder is shown in Figure 25. The proposed interaction framework between the decision-making group and stakeholders is shown in Figure 26 and Figure 27. The difference between Figure 26 and Figure 27 lies in the level of involvement of the decision maker(s) and the stakeholders. Using the Principle of Alignment, the group is equally capable of engaging the stakeholders with or without the presence of the decision maker.

The Principle of Alignment will ensure alignment of strategies for the business enterprise, decision-making groups, and key stakeholders, resulting in a high decision quality. If strategies are not aligned, it is advisable that decisions be made early to allow early remedies to the situation.

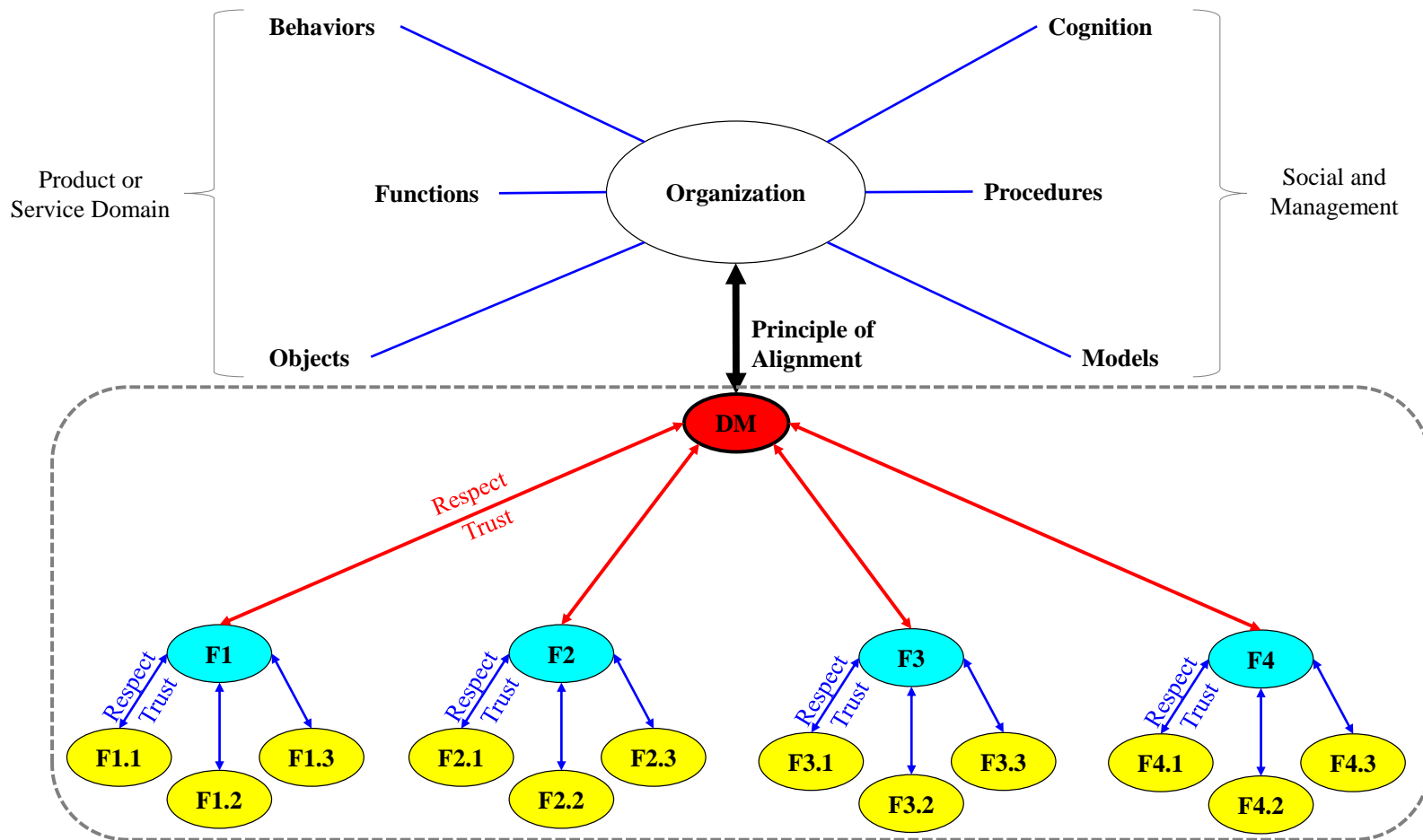


Figure 22. Proposed interaction between decision making group and its parent organization.

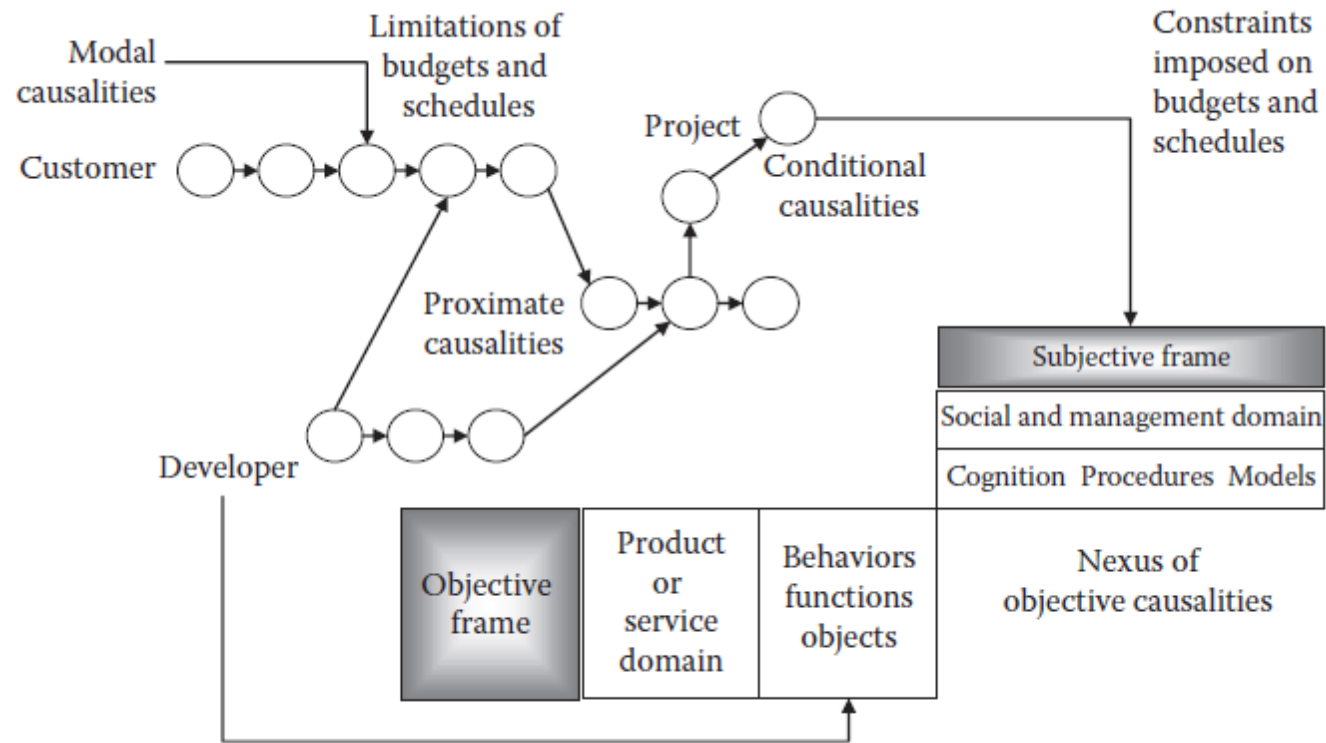


Figure 23. Framework for objective causalities (from Langford 2012).

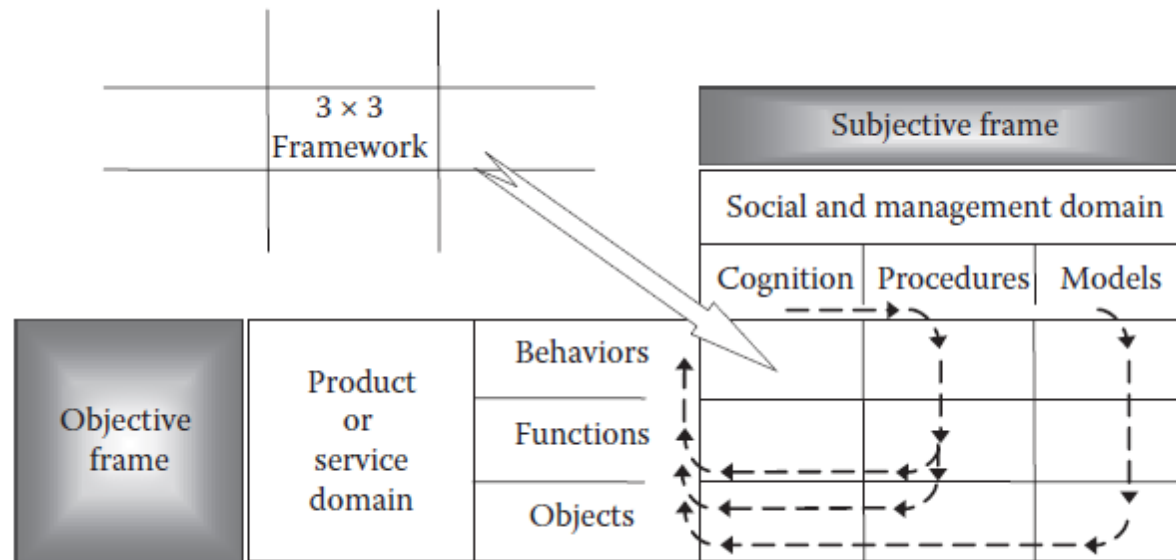


Figure 24. Integrative Systems Framework 3x3 (from Langford 2012).

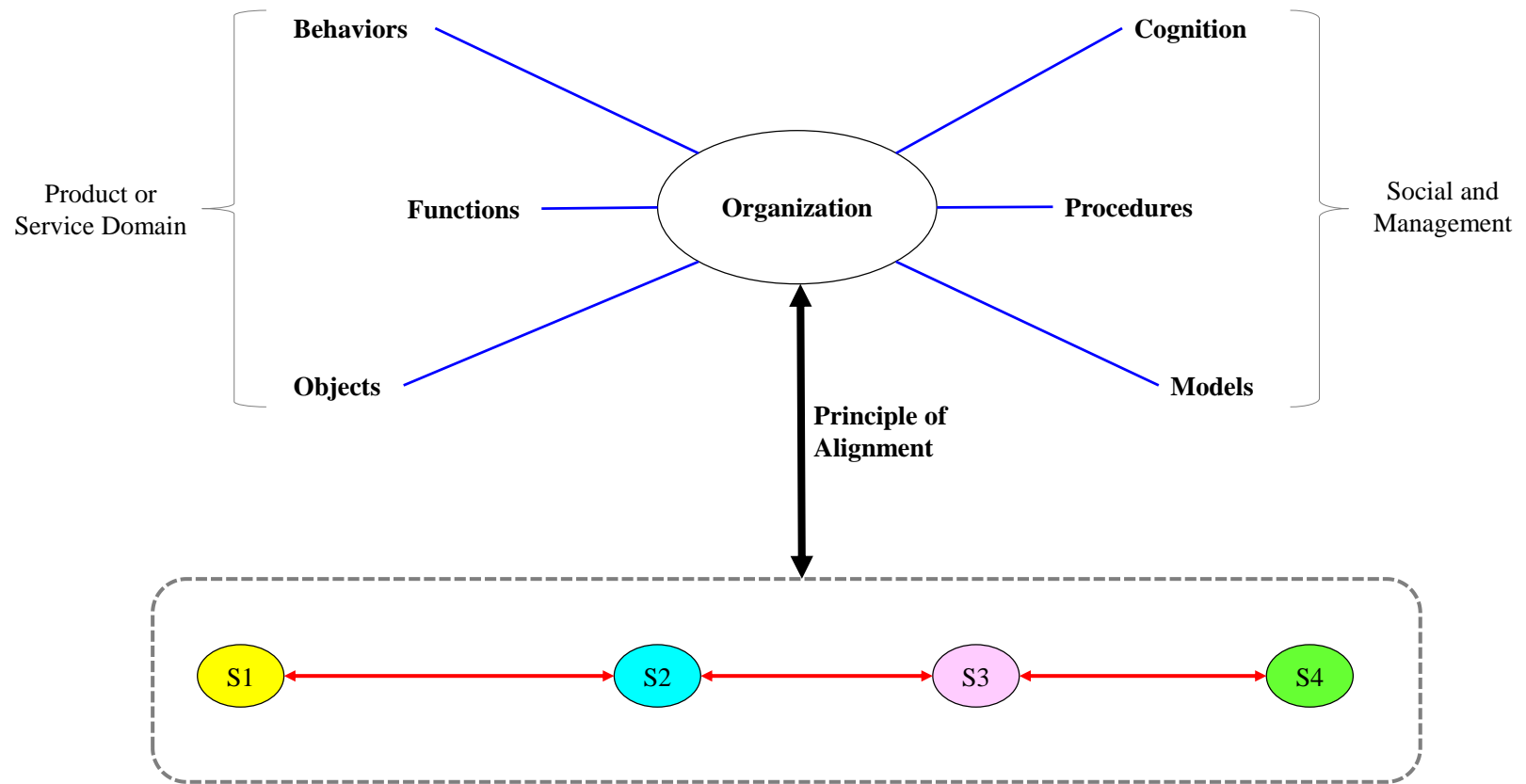


Figure 25. Proposed framework for interaction between organization and key stakeholders.

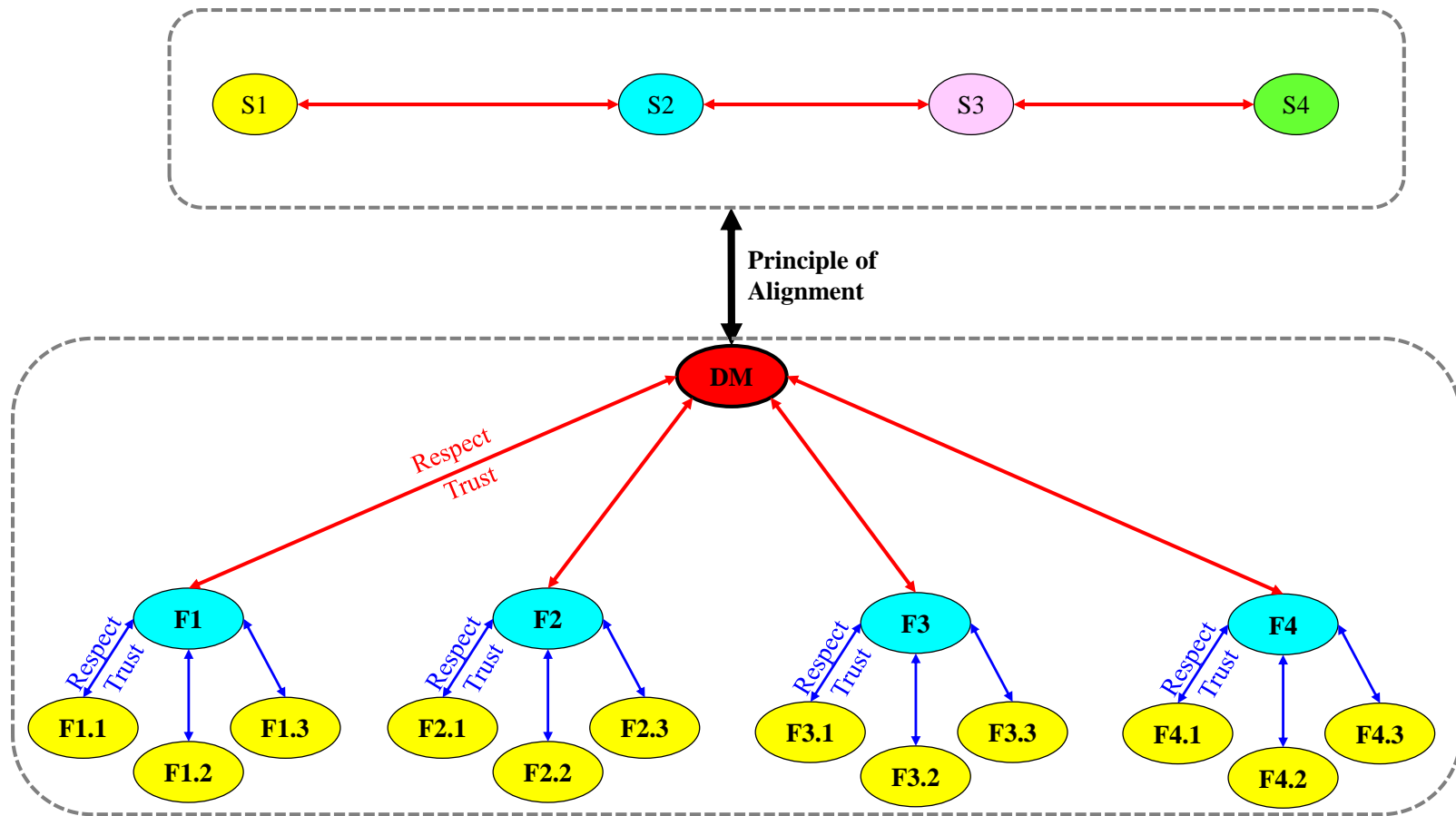


Figure 26. Proposed interaction between decision-making group and key stakeholders – Framework 1.

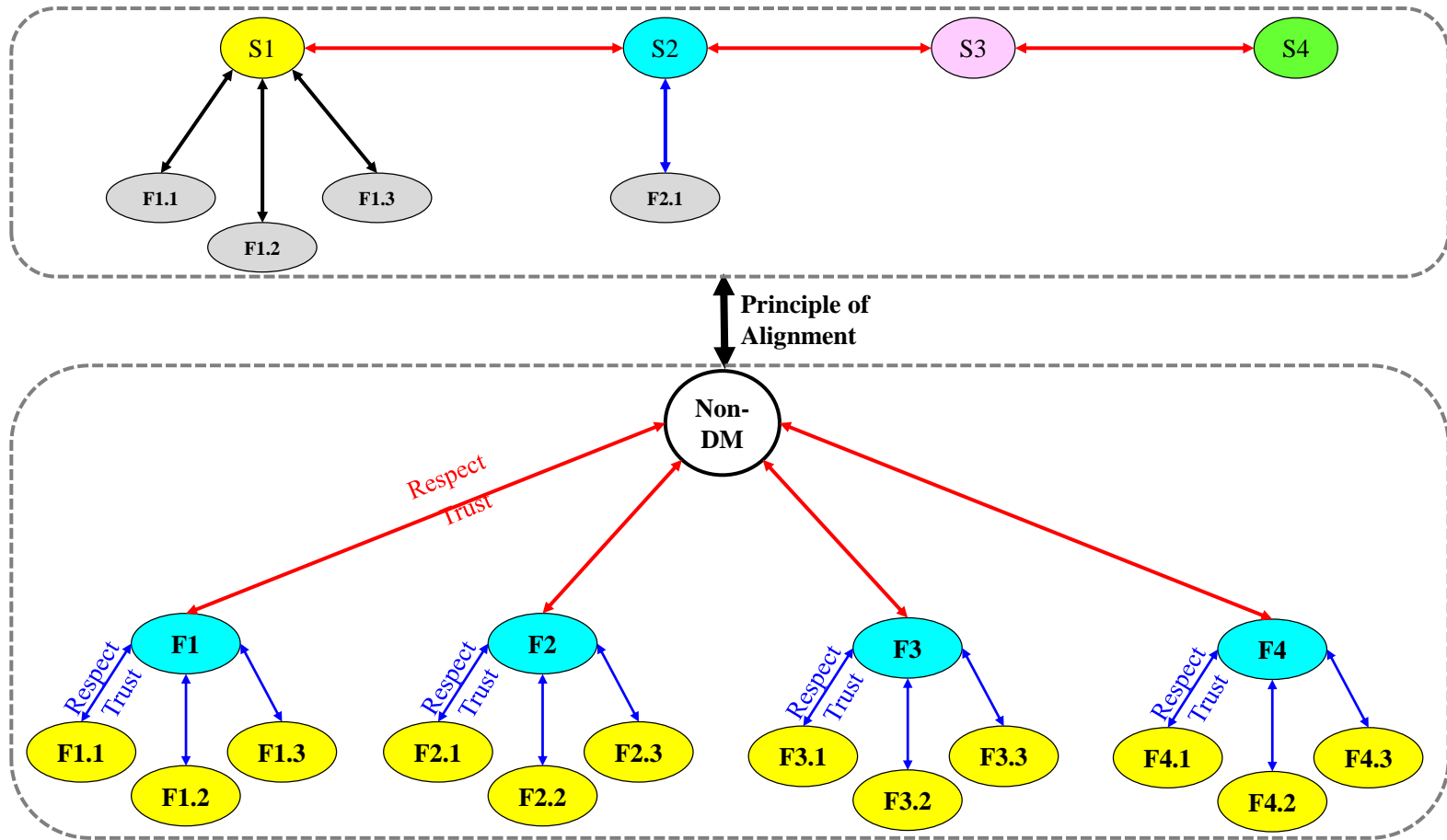


Figure 27. Proposed interaction between decision-making group and stakeholders – Framework 2.

4. Risk

Faced with globalization, industry consolidation, and deregulation, organizations operate in increasingly dynamic, complex, and unpredictable business environments. There are certain levels of risk involved with each group decision made within an organization; because of that, the analysis and management of emerging risk becomes essential (Alchain 1950). Risk management has significant ramifications on the competitiveness and business of an organization (Radner 1996). Organizations need to be able to strategize to reduce potential loss, while exploiting opportunity to maximize gains. Recently, there has been a paradigm shift to a risk-encompassing perspective, which results in a holistic framework referred to as enterprise risk management (ERM) (Brustbauer 2014). This element of risk-taking is only very recently observed in Singaporean decision-making processes. ERM requires the identification, assessment, and monitoring of all threats and opportunities faced by an organization (Pagach and Warr 2011). With the introduction of organization-wide risk-management approaches to generate increased risk-management awareness, mature operational and strategic management decisions can be expected when an organization cleaves to the suggested principles of ERM (Nocco and Stulz 2006). The ERM may appear to be a coping mechanism for effective risk management; however, the knowledge of ERM is beset by uncertainties and inconsistencies (Lundqvist 2014).

The level of risk can be deduced from the matrix of likelihood and consequences displayed in Table 3.

Table 3. Matrix of Likelihood and Consequence.

		Likelihood	
		Low	High
Consequence	Low	Low Risk	Medium Risk
	High	Low Risk	High Risk

Risk is not always easy to evaluate as the two components are usually not directly measurable, and it is important to note that consequences can evolve to become unintended consequences if the risk is not dealt with promptly. Therefore, the *principle of*

partition and *principle of planning* must be adhered to during risk management analysis. The resulting risk mitigation plan may be prioritized, scheduled, and promptly executed at different phases of the group decision.

To determine the level of risk involved, the decision-making group could measure the performance of the output of their decision against the expected quality loss that occurs from the execution of that decision (Langford 2012). Mathematics can simplify the assessment of risk by assuming an idealized negotiation where two parties, for instance, stakeholders and the decision-making group, incur equal losses about a center point target value, m . Figure 28 shows the quality loss function with minimum loss at the target value of the critical performance characteristic, m , as a negotiation between two strategies with opposite demands on decision quality for a given decision situation (Langford 2012).

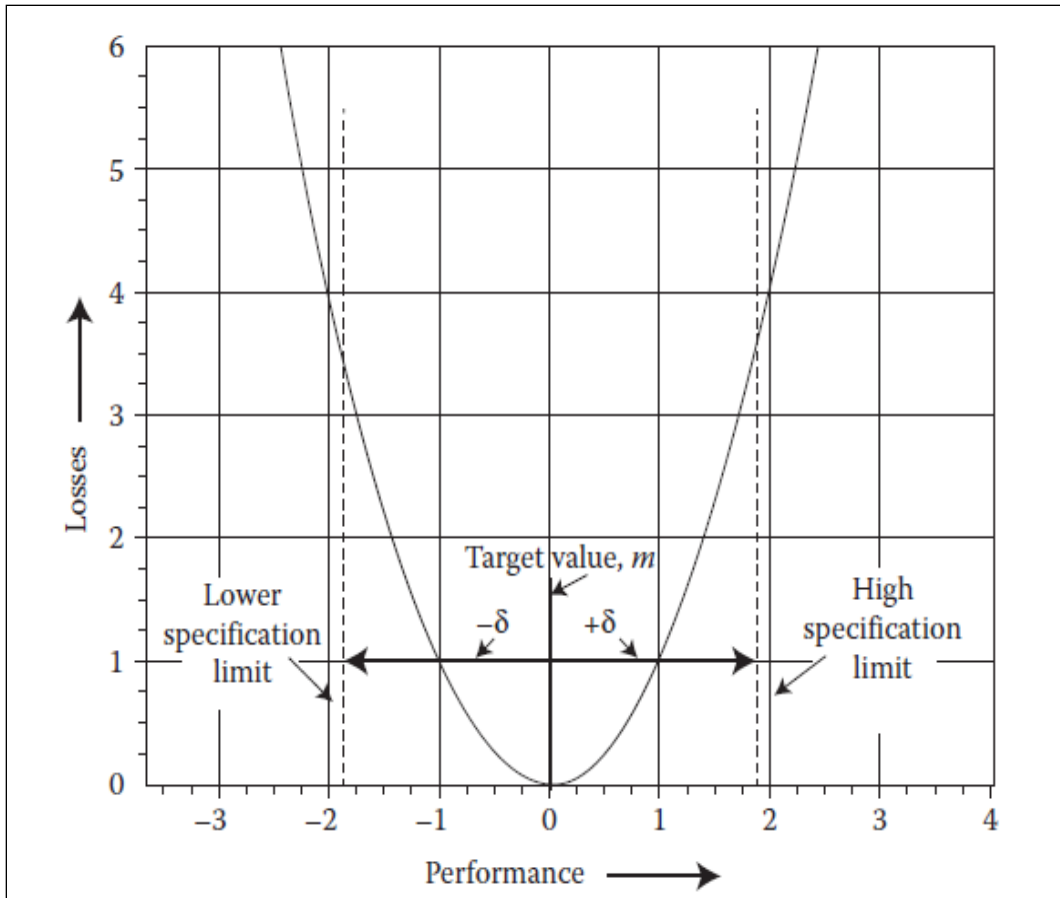


Figure 28. Pareto-efficient negotiation—Quality loss function (from Langford 2012).

Langford (2012) further examines the negotiation between the two parties as follows:

One party to the negotiation determines that more performance is better (considered as larger-the-better (LTB) strategy) while the other party considers that smaller-the-better (STB) demands on performance is required. The LTB (buyer's strategy) benefits from larger values of performance, m , coupled with lower loss. Alternatively, the STB (seller's strategy) faces higher losses from a higher-performance requirement, m . For example, a seller might want to deliver more product performance but is unwilling to accept increased costs which may lead to reduced market share, while the buyer might expect more product performance for lower costs. Figure 29 illustrates LTB and STB strategies plotted with performance indicated on the x-axis and the loss on the y-axis.

Simple addition of the two curves, x and $1/x$, results in a pictorial representation of negotiation, based on both parties achieving the minimum loss. Figure 30 shows the resultant quality loss function.

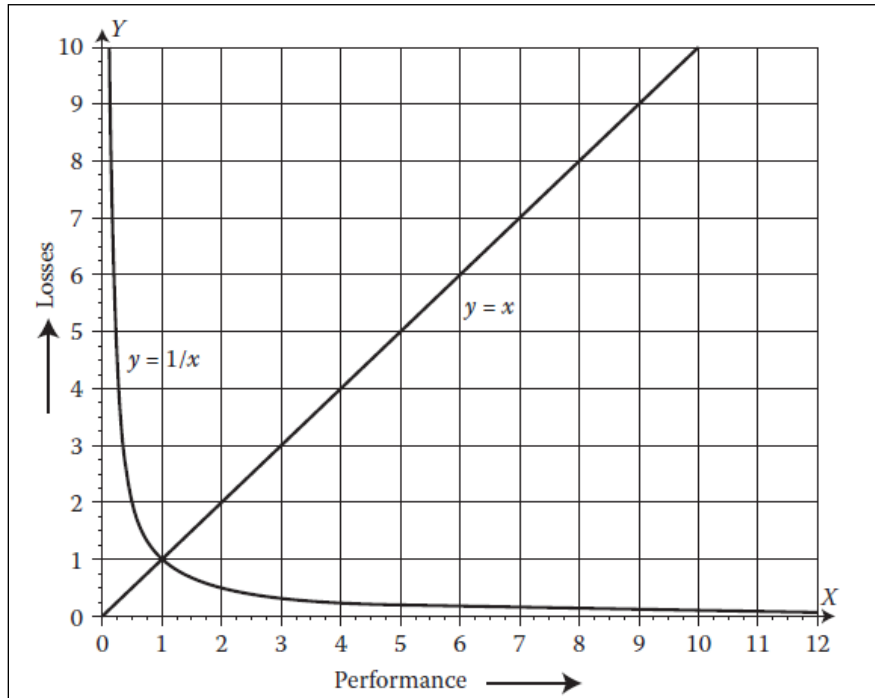


Figure 29. Smaller-the-Better (STB: $y = x$, seller) and Larger-the-Better (LTB: $y = 1/x$, buyer).

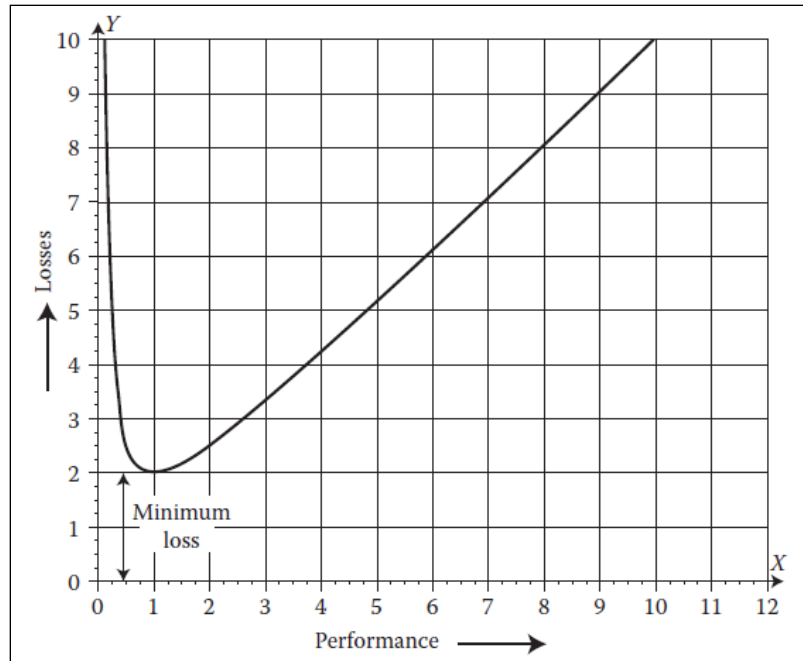


Figure 30. Combining two loss distributions that compete for a definitive product upgrade period, m .

It is recommended that a group decision be made when the measured performance is found to be ± 20 percent of m as shown in Figure 31. This variance will facilitate the stepwise increment of the event that will take place with each decision made to result in lower risk and increased knowledge. With reference to the previously mentioned Event-Space Model, Langford and Lim (2007) have observed:

Once a future Event-Space has been identified, it must be compared in the context with the then current behaviors. The essence of a company's planning is to bring the future back to the present in a step-wise fashion. An essential part of this activity is to determine the needed engineering issues, the changes in technology that must be made in context of the future Event-Space, the changes in consumer behavior, the changes in company operations and competitive strategy, the changes in investment, and the changes in importance to both the provider and the consumer.

Thus, with each trigger for a new group decision to be made, the group must consider the previous decision as part of the new frame for the latest decision situation.

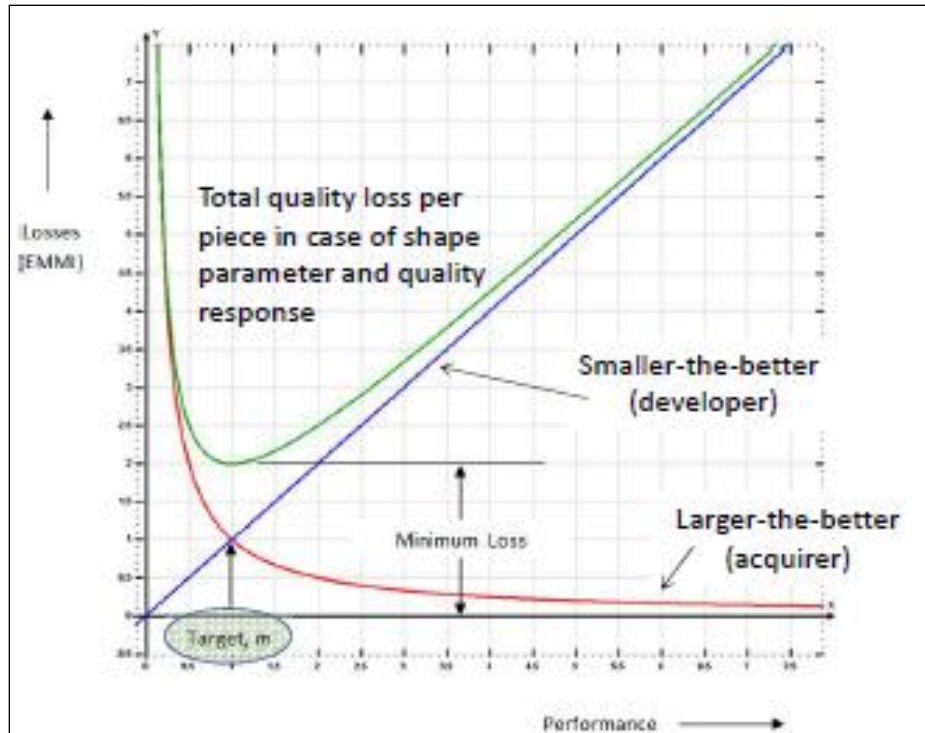


Figure 31. Trigger for making new group decision.

Suppose an organization is faced with a sub-system failure that requires a decision to be made, that is, either to simply fix the failure as a temporary remedy or re-design the sub-system as a permanent solution to the failure. While time is required to investigate the root cause of such a problem, it is recommended that decisions be made early to start the re-design, since the involved minimum quality loss is much lower for re-design than for that of a simple fix. This is shown in Figure 32. Moreover, concurrent execution of a simple fix and re-design work is not advisable as the total cost of quality loss is much higher than any of the quality loss resulting from either of the individual decision options.

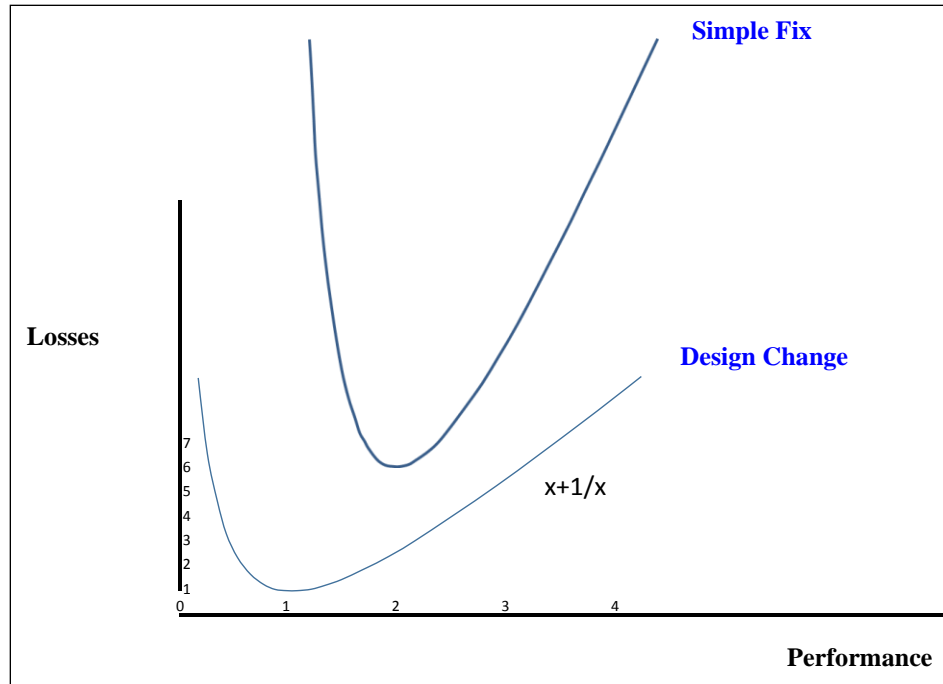


Figure 32. Comparison of loss functions.

While the group decision process is iterative and requires a few decisions to be made in a certain period of time, it is recommended that decisions be made as early as possible. Early decisions are preferred, as these decisions may contain a higher level of risk compared to the subsequent decisions. As time goes by, the level of uncertainty of the decision situation decreases and results in more knowledge gained to cause a lower risk.

5. Heuristics

A heuristic is defined as a rule of thumb that assists in decision making (Ragsdale 2012). Although it may work well in some decision situations, it is not guaranteed to produce optimal solutions or decisions. Optimal decisions are those that a decision maker would consider as the right choice, regardless of whether the decision maker is evaluating his own decisions or those of others (Milkman, Chugh, and Bazerman 2009).

Heuristics used in the generation of the method and framework are described in the following sections.

(1) Heuristic 1: Rule of 7

In practice, the “Rule of 7” applies to the human mind being limited to roughly seven (7 ± 2) simultaneous concepts (Miller 1956). Using this, it is recommended that a decision-making group should consider having 7 ± 2 members. This allows the decision maker(s) to be able to responsively manage concurrent interactions with each functional member.

(2) Heuristic 2: No Satisfactory Way to Aggregate Preferences

With reference to Lecture 4, Applied Utility Theory of Value-Driven Tradespace Exploration for System Design, according to Arrow’s Impossibility Theorem, there is generally no optimal solution to a problem where the involved group of stakeholders has multiple conflicting needs (Ross and Rhodes 2009). In addition, there is no satisfactory way to aggregate or rank preferences without dictatorial or imposed orderings. As a result, negotiation is often required as part of the decision-making process.

V. CONCLUSION

Decision making in a highly competitive environment focuses on cost and time efficiency in delivering the most propitious set of future events. Making a good decision means collecting appropriate and essential information, knowing what level of trust to assign to that information, applying the appropriate framework for evaluating the information, incorporating the ethical and legal aspects with each alternative solution, understanding the risks involved with each alternative before making the decision, and assuring that the decision applies integrally and causally to the problem or question that precipitated the need for a decision. Good decisions do not always result in a desirable immediate outcome, but they generally do have a long-term benefit to the decision maker. The ultimate test for a good decision is when doubts are supplanted with risk-mitigation strategies.

It is just as important to distinguish what constitutes bad decisions. A bad decision is one in which you let your bias guide you; you overlook the ramifications of right versus wrong; you take the most expedient path rather than the longer path to being well-informed and well-grounded; you take risks without consideration of potential losses; you do not consider the experience of others; you have not accounted for your limitations or constraints, and you have violated the principles of common sense. The ultimate test for a bad decision is that you absolutely know it is a bad decision.

While decisions shape the outcome of a group decision in an organization, it is important to realize that errors can be introduced by biases in judgment (Milkman, Chugh, and Bazerman 2009), and these errors can be costly. The power of group-think is to discover the limitations and constraints that underlie the ideas being considered. The power of one is a most effective means of getting to an answer without overly complex or detailed issues encumbering the process.

There are differing views on the realism required to achieve good decision quality; hence, it is crucial to focus on the process of decision making coupled with excellent framing of the decision situation and comprehensive exploration of alternatives

within the solution spaces. It is also recognized that there is no one decision theory, approach, or framework that works best in all situations. It is important to be able to apply the methodology appropriately with respect to the decision situation. This selectiveness will allow decision makers to gain further insight into different aspects of the decision situation and sharpen the acumen of the decision maker(s) of a group in an organization.

Recommendations for group decision making in Singapore are as follows:

- Organization to engage in a centralized communication network, such as, a chain and a wheel network. At the same time, there shall be element of respect and trust in the communication.
- Group decision to be made as early as possible so that it allows buffer for iteration of decision making process to mitigate the involved risks.
- Primary emphasis shall be placed on framing the correct decision situation to ensure that the group has a common understanding of the required group decision.
- Secondary emphasis shall be placed on generation of alternatives or different opinion to ensure that the solution spaces are adequately explored. Also, the pros and cons of the alternatives must be examined.
- 100 percent consensus from the functional representatives must be achieved in a group decision.

LIST OF REFERENCES

- Ackoff, R. L. 1978. *The Art of Problem Solving*. New York: John Wiley & Sons.
- Adams, L. 2005. "A Systems Approach to Human Factors and Expert Decision Making within Canadiana Avalanche Phenomena." Master's thesis, Royal Roads University, Victoria, Canada.
- Alchian, Armen A. 1950. "Uncertainty, Evolution, and Economic Theory." *Journal of Political Economy* 58: 211–221.
- Arrow, K.J. 1974. *The Limits of Organization*, New York: Norton
- Banerjee, A. 2012. "What Are the Important Theories of Decision Making?" <http://www.preservearticles.com/2012051832379/what-are-the-important-theories-of-decision-making.html>.
- Bazerman, M. H. 2006. *Judgement in Managerial Decision Making*. Hoboken, NJ: John Wiley & Sons.
- Bazerman, Max H. and C. Dolly. 2005. *Bounded Awareness: Focusing Failures in Negotiation*. New York: Psychology Press.
- Blanchard, Benjamin S. and W. J. Fabrycky. 2011. *Systems Engineering and Analysis*. New Jersey: Prentice Hall.
- Bloomberg. 2014. *Visual data: Bloomberg Best (and Worst)*. <http://www.bloomberg.com/visual-data/best-and-worst/most-rapidly-aging-countries>.
- Bright, L. S. 2010. "Group Dynamics and Decision Making: Backcountry Recreationists in Avalanche Terrain." Ph.D. dissertation, Colorado State University, Fort Collins, CO.
- Brustbauer, J. 2014. "Enterprise Risk Management in SMEs: Towards a Structural Model." <http://isb.sagepub.com/content/early/2014/07/28/0266242614542853>.
- Busine, Mark, Ian Till, and Nikki Dy-Liacco. 2010. *Leading Singapore: A Snapshot of Leadership Readiness*. Singapore: Development Dimensions International (DDI).
- Cooper, G. and E. Herskovits. 1992. "A Bayesian Method for the Induction of Probabilistic Networks from Data." Knowledge Systems Laboratory, Report KSL-91-02, *Machine Learning* 9: 309–347. doi:10.1007/BF00994110.

- Dale, K. K. 2012. "Perceptions of Organizational Culture of a Multi-Campus Community College District: Mixed Methods in Concert." Ph.D. dissertation, Colorado State University, Fort Collins, CO.
- Development Dimensions International. 2014. *DDI*. Retrieved from <http://www.ddiworld.com/home?lang=en-US>.
- Ellis, D. G. and B. A. Fisher. 1994. *Small Group Decision-making: Communication and the Group Process*. New York: McGraw-Hill.
- Fisher, B. A. 1980. *Small Group Decision-making: Communication and Group Process*. New York: McGraw-Hill.
- Friedman, T. L. 2005. "It's a Flat World, After All." *New York Times*.
<http://www.nytimes.com/2005/04/03/magazine/03DOMINANCE.html?pagewanted=1&r=1>.
- Gregory, S. P., T. Bresnick, S. N. Tani, and E. R. Johnson. 2013. *Handbook of Decision Analysis*. Hoboken, NJ: John Wiley & Sons.
- Hofstede, G. and G. J. Hofstede. 2005. *Cultures and Organizations: Software of the Mind*. New York: McGraw-Hill.
- Gunnarsson, M. 2006. "Group Decision-Making - Language and Interaction." Ph. D. dissertation, Department of Linguistics, Goteborg University, Sweden.
- Halevy, N., T. R. Cohen, E. Y. Chou, J. J. Katz, and A. T. Panter. 2013. "Mental Models at Work: Cognitive Causes and Consequences of Conflict in Organizations." *Personality and Social Psychology Bulletin* 40, no. 1: 92–110.
- Howard, R. A. 1983. "The Evolution of Decision Analysis." In *The Principles and Applications of Decision Analysis*. Palo Alto, CA: SDG Decision Systems, 6–13.
- INCOSE. 2010. *Systems Engineering Handbook*. San Diego: International Council on Systems Engineering.
- Kasser, J. 2013. *Holistic Thinking—Creating Innovative Solutions to Complex Problems*. Cranfield, England: The Right Requirement.
- Kerzner, H. R. 2013. *Project Management: A Systems Approach to Planning, Scheduling and Controlling*. Hoboken, NJ: John Wiley & Sons.
- Langford, G. O. 2012. *Engineering Systems Integration: Theory, Metrics, and Methods*. Boca Raton, FL: CRC Press.

- Langford, G. O. and H. L. Lim. 2007. "Predicting and Assessing Disruptive Technologies using Event Space Modeling." *Asia-Pacific Systems Engineering Conference 2007*. Singapore, March 23–24, 2007.
- Levin Institute. 2014. *Globalization 101*. <http://www.globalization101.org/what-is-globalization/>.
- Lundqvist, S. A. 2014. "An Exploratory Study of Enterprise Risk Management: Pillars of ERM." *Journal of Accounting, Auditing & Finance* 29, no. 3: 393–429.
- McClung, D. M. 2002. "The Elements of Applied Avalanche Forecasting Part I: The Human Issues." *Natural Hazards* 26, no. 2: 131–146.
- Milkman, Katherine L., Dolly Chugh, and Max H. Bazerman. 2009. "How Can Decision-making Be Improved?" *Perspectives on Psychological Science* (July): 379–383.
- Miller, G. A. 1956. "The Magical Number 7, Plus or Minus Two: Some Limits on our Capacity for Processing Information." *The Psychological Review* 63, no. 2: 81–97. doi:10.1037/h0043158.
- Mohammed, S. and E. Ringseis. 2001. "Cognitive Diversity and Consensus in Group Decision-making: The Role of Inputs, Processes, and Outcomes." *Organizational Behavior and Human Decision Processes* 85, no. 2: 310–335. doi:10.1006/obhd.2000.2943.
- Nocco, B. W. and R. Stulz. 2006. "Enterprise Risk Management: Theory and Practice." *Journal of Applied Corporate Finance* 18, no. 4: 8–20. doi:10.2139/ssrn.921402.
- O'Rourke, M. 2005. *Chapter Two: Characterizing Critical Thinking*. http://www.webpages.uidaho.edu/crit_think/Chapter-Two-1.htm.
- Pagach, D. and R. Warr. 2011. "The Characteristics of Firms that Hire Chief Risk Officers." *Journal of Risk and Insurance* 78, no. 1: 185–211. Doi:10.1111/j.1539-6975.2010.01378.x.
- Paul, Richard, Robert Niewoehner, and Linda Elder. 2007. *The Thinker's Guide to Engineering Reasoning*. Tomales, CA: Foundation for Critical Thinking Press.
- Peterson, M. 2009. *An Introduction to Decision Theory*. Cambridge, UK: Cambridge University Press.
- Quizlet. 2014. "GroupThink." <http://quizlet.com/7519519/groupthink-symptoms-and-remedies-flash-cards/>
- Radner, Roy and Larry Shepp. 1996. "Risk vs. Profit Potential: A Model for Corporate Strategy." *Journal of Economic Dynamics & Control* 20: 1373–1393. doi:10.1016/0165-1889(95)00904-3.

- Ragsdale, C. T. 2012. *Spreadsheet Modeling & Decision Analysis*. Mason, OH: South-Western Cengage Learning.
- Sinclair, A. 1992. "The Tyranny of a Team Ideology." *Organization Studies* 13: 611–626.
- Scott, W. R. 2003. *Organizations: Rational, Natural, and Open Systems*. New Jersey: Prentice Hall.
- Stasser, G. and W. Titus. 1985. "Pooling of Unshared Information in Group Decision-making: Biased Information Sampling during Discussion." *Journal of Personality and Social Psychology* 48, no. 6: 1467–1478. doi:10.1037/0022-3514.48.6.1467.
- Strategic Decisions Group. 2014. Lecture. *DQ101 Introduction to Decision Quality*. Naval Postgraduate School, Monterey, CA.
- Sztompka, P. 1974. *System and Function: Toward a Theory of Society*. New York: Academic Press.
- Versluis, V. 2011. *Risk Management and Decision Theory—A Promising Marriage between Two Wholly Remarkable Characters of Mind-boggling Lineage*. Ph. D. dissertation, Department of Business Economics, Rotterdam University, Rotterdam.
- The Whitney and Betty MacMillan Center for International and Area Studies at Yale. 2014. *YaleGlobal Online: Globalization 3.0 Has Shrunk the World to Size Tiny*. <http://yaleglobal.yale.edu/content/globalization-30-has-shrunk-world-size-tiny>.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
Ft. Belvoir, Virginia
2. Dudley Knox Library
Naval Postgraduate School
Monterey, California